SAYING ‘AU REVOIR’ TO ANXIETY IN A HEARTBEAT: THE BENEFITS OF VIRTUAL REALITY FOR LANGUAGE LEARNING.

BY

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DISSERTATION

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ABSTRACT

Computer Assisted Language Learning researchers have been exploring the use of virtual reality (VR) for foreign language learning. Studies have shown that language learners enjoy VR and that it can lead to lower foreign language anxiety (FLA) (Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Kaplan & Wojdynski, 2018; Liaw, 2019; Peixoto et al., 2021; York et al., 2021). However, this exploratory research has relied solely on participants' feedback and has yet to empirically measure learners' anxiety (both self-reported and physiological) in VR environments. Moreover, it has yet to establish whether the lower anxiety that VR affords actually leads to better language performance. Lastly, there has also been a call to examine how students' peer-to-peer interactions during interpersonal tasks differ in VR compared to other learning environments (Lan et al., 2015; Parmaxi, 2020). This study addressed these gaps by examining how French learners' self-reported and physiological anxiety (measured via heart rate) fluctuated across three learning environments: VR, *Zoom*, and a face-to-face classroom. It also examined how lower anxiety impacted learners' oral production at the levels of pronunciation, fluency, and complexity during peer-to-peer speaking tasks.

Thirty-eight (*N* = 38) learners of French enrolled in a course designed to develop Advanced French oral proficiency participated in this study. At the onset, participants' background and baseline self-reported anxiety were established via a background and foreign language anxiety questionnaire. Participants then completed six rounds of comparable 20-minute three-way peer-to-peer interpersonal consensus building tasks in French over a 12-week period in three different environments: two in a classroom, two in *Zoom* and two in the social VR application, *vTime XR*. All tasks were video recorded for further analyses. Participants' heart rate was continuously tracked during each task using Polar OH1 heart rate monitors. Immediately after each task, participants self-reported their anxiety via a questionnaire. Upon completing the final task, semi-structured interviews were conducted to understand participants' perceptions of the three learning environments.

Participants' self-reported anxiety data and physiological measures indicated that learners, particularly those who were more anxious initially, were less anxious overall in virtual spaces. Participants were also found to be more comprehensible, intelligible, and fluent in VR and when they were less anxious, confirming the beneficial impact of VR for language learning and the need to alleviate anxiety in learners to enable them to be more successful. Furthermore, analyses of how focus group participants' heart rates evolved throughout activities in response to their unfolding conversations and the surrounding environment brought to light various factors within each learning environment that both alleviated and worsened anxiety. Finally, participants' insights into how they experienced the three environments indicated that learners were overall more at ease in the virtual environments, but that they perceived many drawbacks of using *Zoom* and found that VR more closely resembled in-person interactions and provided a contextually relevant setting, suggesting that it could offer a better solution to online learning.

To mom and dad

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CHAPTER 1: INTRODUCTION

Students currently entering higher education and university foreign language classrooms are part of Generation *Z* (i.e., born between 1995 and 2010) (Seemiller, 2017). These students come into the classroom with a lot of strengths, and as "digital natives," are often equipped to incorporate the use of technology into their learning. However, this generation also faces certain challenges as students. Indeed, Generation *Z* has been found to have the highest rate of diagnosed anxiety amongst all generations (Schroth, 2019; Seemiller & Grace, 2019). Scholars have attributed this higher anxiety to the environment that these learners have grown up in, which has included events such as 9/11 and the constant use of social media (Schroth, 2019; Seemiller & Grace, 2016). Moreover, the past two years of these students' educational experiences have been remarkably shaped and redefined by the COVID-19 crisis, which could have further exacerbated their already existing anxiety (Elshami et al., 2021). Indeed, the COVID-19 pandemic forced the vast majority of language learning to occur virtually at a distance and for educators to rethink how to use online learning environments effectively.

In terms of language learning specifically, it can be hypothesized that Generation *Z*'s high rate of general anxiety could lead to higher foreign language anxiety (FLA), as general social anxiety and FLA have been found to be related (Botes et al., 2020; MacIntyre, 1995). FLA has been defined as "the worry and negative emotional reaction aroused when learning or using a second language" (MacIntyre, 1999, p. 27), and research has shown that it can have a debilitating effect on language learning. Specifically, three recent meta-analyses on FLA research have consistently shown that FLA significantly negatively correlates with foreign language achievement (Botes et al., 2020; Teimouri et al., 2019; Zheng, 2019). Moreover, FLA has been found to negatively impact learners' oral production at the level of both pronunciation and fluency, which are both crucial for oral communication in a foreign language (Aida, 1994;

Castillejo, 2019; Feigenbaum, 2007; Khoroshilova, 2016; MacIntyre & Gardner, 1994a; Sanaei et al., 2015; Szyszka, 2017).

Although anxiety has been the most extensively studied emotion in SLA research (Boudreau et al., 2018; Dewey et al., 2018; MacIntyre, 2017), it has largely been examined as a fixed construct (MacIntyre, 2017; Saghafi & Shirvan, 2020), and there has been a call for research examining anxiety through a more dynamic lens in order to account for how it fluctuates in response to various factors such as learning environments and interpersonal communication (Dewaele & Alfawzan, 2018; Dewey et al., 2018; Gkonou et al., 2017; Gregerson et al., 2014; Kasbi & Shirvan, 2017; MacIntyre, 2017, MacIntyre & Vincze, 2017; Saghafi & Shirvan, 2020; Sampson, 2019; Shirvan & Talebzadeh, 2017 & 2020). Moreover, scholars have specifically called for complementing self-reported anxiety data, which have dominated the field thus far, with more objective physiological measures of anxiety, such as heart rate (Boudreau et al., 2018; Lan et al., 2018; Scoval, 1978; Teimouri et al., 2019). Triangulating physiological measures with self-reported data would allow to objectively examine both fluctuations in anxiety in real time and learners' perceptions of their emotions.

Given the negative impact of FLA on learning, researchers in the field of Computer Assisted Language Learning have been exploring whether virtual reality (VR) technology could be used to alleviate FLA (Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Liaw, 2019; Xie et al., 2019; York et al., 2021). In second language research, VR has been defined as "any simulated […] environment [that] allows learners to be transported to an immersive target language culture experience" (Kessler, 2017, p. 205). Indeed, with VR technology rapidly advancing and developing, the use of VR for language learning has received ample attention in the past few years, with many researchers specifically examining how it impacts affective factors (e.g., anxiety) (Allcoat & Muhlenen, 2018; Chateau et al., 2019; Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Kaplan-Rakowski & Wojdynski, 2018; Liaw, 2019; O'Brien et al., 2008; Peixoto et al., 2021; Xie et al., 2019; York et al., 2021; Ziegler, 2016).

Thus far, research has largely supported the fact that VR benefits learners by reducing anxiety, particularly during speaking tasks (Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Liaw, 2019; Xie et al., 2019; York et al., 2021). However, the majority of the work done has relied solely on participants' qualitative feedback regarding their anxiety and has not empirically measured – either via quantitative questionnaires or physiological data – how VR impacts FLA. Moreover, there has been a call for research that provides empirical evidence as to whether VR tools can specifically improve students' oral production and pronunciation (Xie et al., 2019). Furthermore, there has been a push for research that accounts for ecological validity by examining how learners collaborate in VR in the context of a course instead of a research lab (Andujar & Buckner, 2019; Lan, 2020; Liaw, 2019; Parmaxi, 2020; Zheng et al., 2017. Finally, CALL researchers have argued for the merging of both qualitative and quantitative research methods in order to develop a holistic understanding of how VR impacts FLA (Ziegler, 2016).

The current study aimed to address these gaps in research by employing mixed methods to explore whether and how immersing foreign language French learners in a VR environment impacts anxiety during spontaneous interpersonal oral production compared to a traditional classroom environment and *Zoom*. In order to respond to the call for more objective anxiety measures in FLA research, this study complemented subjective self-reported anxiety questionnaires with heart rate data from participants. Moreover, the impact of anxiety on oral production (i.e., comprehensibility, intelligibility, fluency, and participants' group conversations) was examined in order to investigate whether and how this emerging technology can potentially enable language learners to be more successful when speaking. Finally, in order to account for participants' perceptions of the three learning environments and how each one impacted their anxiety and learning in the greater context of the surrounding COVID-19 pandemic, qualitative semi-structured interviews were conducted with participants and analyzed.

Finally, it should be noted that this study took place over three semesters: Fall 2020, Spring 2020, and Fall 2021. Due to the ever-evolving nature of the pandemic and university guidelines, the modality of the course that this study was conducted within changed slightly each semester. Any instances where this occurred have been indicated throughout the rest of this dissertation using footnotes.

CHAPTER 2: LITERATURE REVIEW

Theoretical Framework

Sociocultural Paradigm

The current study was framed within a sociocultural paradigm, which conceives of language as a social skill that is inseparable from experiences, emotions, cultural knowledge, and self-identity (Atkinson, 2002; Satar & Ozdener, 2008). Moreover, sociocultural theory stresses the importance of social interactions in language learning, arguing that interactions and collaboration, especially when they occur in a relevant, appropriate context (Lin et al., 2015), ultimately spur learning (Gánem-Gutiérrez, 2018; Grazzi, 2018; Satar & Ozdener, 2008). In fact, Remesal and Colomina (2013) specifically argue that “the sociocultural perspective cannot forget that learning does occur in the social context, which emphasizes the importance of the group-focused dimensions” and the learning environment (p. 365).

With regards to using immersive virtual environments for language learning, Reinhardt (2019) argues that “a social-informed [research] perspective” is especially appropriate, as it recognizes that L2 learning can occur through “negotiation” with other learners within these environments (p. 109). Similarly, Satar and Ozdener (2008) also posit that these environments can foster social interaction in an authentic context that, in turn, leads to negotiating meaning and forming relationships with others. Moreover, Remesal and Colomina (2013) also argue that the construct of *social presence* -- or the feeling of being physically in the virtual space -- should be examined from a socio-cultural perspective and that the heightened presence that learners experience in virtual spaces can create “positive relational dynamics, and the enhancement of self and collective efficacy in front of the learning task, so that the learning process is supported” (p. 357). This study therefore aimed to explore how learners’ group interactions and learning experiences were supported by three different learning environments, two of which were virtual (VR, *Zoom*, and a traditional classroom).

This study was also centered around three theories: Complex Dynamic Systems Theory (CDST), Ecological Systems Theory (EST), and the Broaden-and-Build Theory (BBT). Both CDST and EST are particularly fitting for examining the role of anxiety in language learning, as they contend that "language learning is an emotionally and psychologically dynamic process that is influenced by a myriad of ever-changing variables and emotional 'vibes'" (Gregersen et al., 2014). Furthermore, the BBT contends that positive emotions (e.g., lower anxiety) are beneficial for learning, and that they lead to better performance and problem-solving during tasks (Boudreau et al., 2018; Gregerson et al., 2014; Isgett & Frederickson, 2015).

Complex Dynamic Systems Theory (CDST)

Scholars have recently pushed for adopting a CDST framework when examining how learners' emotions interact with the language learning process (Boudreau et al., 2018; de Bot, 2017; Larsen-Freeman, 2012 & 2017; Shirvan & Talebzadeh, 2017). CDST contends that language learning is a dynamic system, which subsequently is characterized by several distinct properties. Indeed, dynamic systems change and fluctuate over time in response to what occurs before and after a certain time period. Furthermore, all components of the system interact and respond to each other, meaning that due to the butterfly effect, a seemingly small event can create a larger impact on the system. Lastly, dynamic systems self-organize into a) *attractor* states, or momentarily stable states when the language systems settles, and b) *repellor* states or moments when the language system is actively changing (Boudreau et al., 2018; de Bot, 2017; Larsen-Freeman, 2012 & 2017; Shirvan & Talebzadeh, 2017).

Therefore, CDST argues that neither acquisition nor learner characteristics are linear or constant (de Bot, 2017; Larsen-Freeman, 2017), and that the environment in which learning occurs fundamentally influences the learning experience. Indeed, according to Larsen-Freeman (2017), CDST's leading researcher in the field of L2 research, researchers *must* consider the speaker's environment, particularly how it interacts with emotions, as learners' emotions fluctuate and change over time throughout learning due to environmental and situational factors (Dewaele & Dewaele, 2017; Shirvan & Talebzadeh, 2017; Shirvan et al., 2020; Szyszka, 2017). Moreover, emotions are embedded in sociocultural interactions which are highly dynamic and interactive, making it very likely that they will fluctuate over the course of an L2 interaction (Dewaele & Pavelescu, 2021).

Furthermore, emotions are particularly well-suited to be studied using a CDST approach, as "any event or situation can elicit multiple emotions, both positive and negative, which adds to the richness and depth of the human emotional experience" (Isgett & Frederickson, 2015, p. 864). Emotions are also dynamic systems that fluctuate across time in conjunction with one another and in reaction to feedback from their environments (i.e., they are context dependent) (Shirvan & Talebzadeh, 2020). For example, learners can enter a classroom feeling anxious due to being unprepared, but quickly feel at ease due to the way a teacher responds, and then become anxious again when having difficulty expressing themselves in the foreign language. Gregerson et al. (2014) even explain that language learning is an inherently emotional process, due to the fact that the brain is constantly evaluating the surrounding external factors, such as the learning environment and those we are interacting with, but that there has unfortunately been a "disconnect between the moment-by-moment ways languages are learned and used versus how emotional processes are conceptualized and studied in the literature" (p. 575). Consequently, the authors specifically call for research to adopt new methods, notably physiological responses such as heart rate (see also, Meer et al., 2016), that can capture fluctuations in anxiety and study the emotion "as a dynamic system of variables that interact at a given moment in time" (p. 576; see also, Gkonou et al., 2017).

Moreover, Boudreau et al. (2018) argue that SLA research has examined emotions such as anxiety as "relatively stable individual difference[s]" for far too long (p. 149; see also, Mahmoodzadeh & Gkonou, 2015), despite emotions being "ideal candidates to be studied from a dynamic perspective" (p. 154). Concerning the relationship between emotions and L2 oral production, Boudreau et al. (2018) further explain that "Unfolding interpersonal contexts that feature communication and facilitate language learning make emotions especially relevant as changes in emotion trajectories interact between/among persons, and at times can lead to rapid and dynamic changes in the social context" (p. 150). Moreover, MacIntyre and Vincze (2017) argued that "the dynamic interaction of positive and negative emotion during language learning and communication processes, that is, their coordinated effects in real time at the individual level, would […] be an especially interesting avenue of research" (p. 82). The current study therefore triangulated multiple variables (e.g., participants' heart rate and unfolding group interactions) to track how anxiety fluctuated for language learners in response to their evolving peer-to-peer conversations.

Ecological Systems Theory (EST)

EST complements CDST, making it particularly relevant for the current study. Indeed, EST also "emphasizes the role of the immediate setting and larger social environment in human development" (Blin, 2016, p. 42), while viewing language learning and use as "complex and systemic, but also non-linear and emergent" (Reinhardt, 2019, p. 111). Consequently, EST argues that we cannot study language learning or use "as an isolated object, but that research should account for: (a) the social relationship among learners engaging in meaning-making activities: (b) the impact of the tools [i.e., technology] and the environment on their L2 acquisition process; and (c) their perception of (a) and (b)" (Mroz, 2015, p. 530), as all of these variables combine and interact with each other to produce the language learning experience.

Specifically, scholars taking an ecological approach to the study of FLA conceive of the various internal and external factors that surround language learning as making up layers of an ecosystem (Bronfenbrenner, 1979; Kasbi & Shirvan, 2017; Rani, 2020; Saghafi et al., 2017). This ecosystem, or what Bronfenbrenner (1979) called the *macrosystem*, is composed of various subsystems: the *microsystems* (e.g., the classroom, learner beliefs), the *mesosystems* (e.g., past experiences, extracurricular activities), and the *exo-systems* (e.g., the course curriculum, funding sources) (Kasbi & Shirvan, 2017; Rani, 2020; Saghafi et al., 2017). According to EST, various factors in all of these systems can interact and influence language learning. Indeed, according to Saghafi et al. (2017), "an ecological perspective indicates that a learner is an organism within his or her surrounding environment, any fluctuations in his or her behavior echoes through the environment and the involved parties" (pp. 435-436). Consequently, scholars who adopt an ecological approach when studying learners' emotions argue that research must account for the interaction of these subsystems in order to accurately portray the role of emotions in the language learning process (Kasbi & Shirvan, 2017; Rani, 2020; Saghafi et al., 2017).

Recently, scholars have argued for the need to specifically shift Computer Assisted Language Learning (CALL) research towards an ecological approach to examine whether and how certain technology-based environments impact emotional factors (e.g., anxiety) (Blin, 2016; Dewey et al., 2018), as these "emotional factors" tend to fluctuate and "cannot easily or clearly be [...] [classified as] ‘positive’ or ‘negative’” (van Lier, 2004, p. 140). Furthermore, EST also aligns particularly well with the type of embodied cognition that may be found in VR-based language learning, “as it views cognitive representations developing via embodied interactions with virtual resources perceived as part of the environment” (Reinhardt, 2019, p.111).

Moreover, it has been argued EST is particularly suitable when examining learners' foreign language speaking anxiety. According to Kasbi and Shirvan (2017), using EST to study “learners' speaking anxiety in terms of the interconnection [...] with their surrounding environment can provide [...] new insights into uncovering agents or affordances contributing to the emergence of their speaking anxiety” (Kasbi & Shirvan, 2017, p. 2). Indeed, the emergence of foreign language speaking anxiety is complex, with “the processes and patterns of speaking anxiety [not being] [...] sequential; they [...] emerge differently for different learners in different timescales” (Kasbi & Shirvan, 2017, p. 2). Consequently, we must take into account the entire ecosystem (e.g., peers, teachers, past experiences, personality differences, etc.) that encompasses the learning process (Shirvan et al., 2020). Taken together, the current study aims to explore how the various elements and characteristics of three different learning environments – VR, *Zoom*, and a traditional classroom – interact both positively and negatively with learners' anxiety during speaking tasks.

Broaden-and-Build Theory (BBT)

This study also relied on the Broaden-and-Build Theory (BBT) when arguing that lower anxiety can lead to positive emotions that ultimately lead to better learning, problem solving and performance (Boudreau et al., 2018; Gregerson et al., 2014; Isgett & Frederickson, 2015; Shirvan et al., 2020). Indeed, according to Barbara Frederickson, who founded the BBT in the late 1990's, “positive emotions momentarily expand our perception of the world in ways that facilitate global visual processing, better attentional flexibility, and larger thought-action repertoires" (Isgett & Frederickson, 2015, p. 864; see also, Gregerson et al., 2014).

More specifically, Frederickson breaks the BBT into two key hypotheses: (1) broaden and (2) build. First, she argues that the "broaden effect" occurs when positive emotions "have momentary effects on cognition and behavior that expand our awareness and repertoire of what we want to do" (Isgett & Frederickson, 2015, p. 864). In terms of language learning, this can be beneficial by leading learners to have a higher willingness to communicate and take more risks when speaking the foreign language. Subsequently, "the build effect" argues that these "moments of broadened awareness, sparked by positive emotions, accumulate and compound to build people's personal resources, whether social, emotional" (Isgett & Frederickson, 2015, p. 864). This can be particularly valuable for language learning, as the compounding effect of these positive emotions can transcend later L2 interactions and lead to beneficial long-term effects, such as learners being more willing and less anxious to communicate during real-world interactions. Moreover, Isgett and Frederickson (2015) explain that learners who have accumulated more positive emotions will also recover -- both mentally and physiologically -- more quickly from negative emotions (e.g., stress & anxiety).

Informed by these three theories, the current study argued that both environmental and learner differences could potentially and dynamically influence anxiety in participants engaged in spontaneous interpersonal (i.e., peer-to-peer) oral production tasks. Specifically, this study hypothesized that L2 French learners' anxiety could be positively impacted by being immersed in virtual environments that might be considered as less face-threatening than a traditional face-to-face classroom environment and that this would consequently lead them to produce more comprehensible, intelligible, and fluent speech. These three variables are notably important as they directly determine how well L2 speakers are understood by listeners (Derwing & Munro, 2015).

Foreign Language Anxiety

Before defining foreign language anxiety, it is important to first understand what constitutes an emotion. To put it simply, "emotions are brief, multisystem responses to the way individuals appraise their current circumstances [...] [they] allow our minds to adapt to the surrounding social or physical environment" (Isgett & Frederickson, 2015, p. 864). They are affective processes and are "generally considered to be adaptive responses to personally significant events. They differ from moods, which are relatively diffuse and often disconnected from a specific event or object, whereas emotions are acute reactions to specific events or objects" (Mikels & Lorenz, 2019, p. 545). Emotions also can be divided into two main categories: basic and complex emotions (Psychology Today, 2018). Basic emotions are associated with universally recognizable facial expressions and include sadness, anger, fear, disgust, contempt, joy, and surprise whereas complex emotions include feelings such as grief, regret, and jealousy (Psychology Today, 2018). These different emotions vary across several dimensions (temporality, social vs non-social, dynamicity, complexity) (Mikels & Lorenz, 2019).

Taking this complexity of emotions into account, Gregerson et al. (2014) explain that emotions are "coordinated reaction[s]" between "subjective feelings, biological/physical reactions, purposive goal-directed behavior, and a social competent that guides emotional expression and interpretation", and that all of these combined can "continually influence language learners' moment-by-moment affective processes even if we [they] are not aware of feeling a specific emotion" (p. 575; see also, Mikels & Lorenz, 2019). Moreover, according to Heeran et al. (2012), both positive and negative emotions can be expressed in three ways: (1)

overt behaviors (e.g., avoiding a task or using a language), (2) language (e.g., self-reporting) and (3) physiological responses (e.g., heart rate).

Anxiety is an emotion of particular interest to advance research in the field of second language acquisition, particularly during the COVID-19 crisis when students' anxiety is heightened. In terms of classifying anxiety amongst other emotions, it has been argued that anxiety stems from the core basic emotion "fear" (Cisler et al., 2010; National Alliance on Mental Illness, 2021). Indeed, "'Fear' refers to an emotional system motivating defense behaviors elicited from a specific threat cue; [whereas] 'anxiety' refers to an emotional system motivating defense behaviors elicited from an impending non-specific threat cue" (Cisler et al., 2010, p. 69). In other words, anxiety is a physiological reaction to the emotion fear. Moreover, anxiety is an enduring "affective predisposition or trait" that can "predispose a person to certain characteristic emotional responses" (Mikels & Lorenz, 2019, p. 545).

The field of psychology has further identified three separate types of general anxiety: trait, state, and situation-specific anxiety (Baralt & Gurzynski-Weiss, 2011; Dewaele & Alfawzan, 2018). While *trait* anxiety is considered to be a personality characteristic or a pre-disposition to be more anxious, *state* anxiety "refers to the way in which the learner feels at a particular moment in response to a situation" (Baralt & Gurzynski-Weiss, 2011, p. 202). On the other hand, situation-specific anxiety has been defined as anxiety that arises during a specific type of situation, such as an oral presentation. In terms of these three classifications, foreign language anxiety (FLA) has been characterized as a situation-specific anxiety, as it only occurs in a limited range of settings (i.e., when the foreign language is used) (Botes et al., 2020; Dewaele, 2013; Dewaele & Alfawzan, 2018; Gkonou et al., 2017; Zheng & Cheng, 2018).

However, although FLA can be considered a separate construct, previous research does indicate a relationship between FLA and social anxiety. Social anxiety has been defined as "clinically significant anxiety provoked by exposure to certain types of social or performance situations, often leading to avoidance behavior" (American Psychiatric Association, 2000, p. 429). According to MacIntyre (1995), FLA is related to social anxiety, as it "stems primarily from the social and communicative aspects of language learning and therefore can be considered as one of the social anxieties" (p. 91; see also, Botes et al., 2020). Therefore, it could be expected that learners who experience social anxiety are more likely to also experience foreign language anxiety.

FLA has commonly been defined as the "worry and negative emotional reaction aroused when learning or using a second language" (MacIntyre, 1999, p. 27). FLA has been by far the most extensively researched emotion in SLA (Boudreau et al., 2018; Dewey et al., 2018; MacIntyre, 2017), with studies continuously underlining the debilitating effect it can have on language learners' success (Botes et al.., 2020; Teimouri et al., 2019; Zheng 2019). Indeed, three recent meta-analyses of FLA research have found a negative, moderate correlation between FLA and foreign language achievement. Specifically, in their 2019 meta-analysis on 97 studies, Teimouri et al. found a negative correlation of -.36, leading the researchers to conclude that FLA accounts for roughly 13% of language learning success or failure. Zhang (2019) similarly found a negative correlation of -.34 in his meta-analysis of 55 studies. Finally, Botes et al. (2020) most recently conducted a meta-analysis of 67 studies and found a negative correlation between FLA and all general foreign language achievement of -.39. When breaking it down by skill type, the researchers found a negative correlation between FLA and all four skills: reading (r = -.34), writing (r = -.44), listening (r = -.53) and speaking (r = -.26). Given these results, and the fact that over half of students taking language courses experience debilitating anxiety that can ultimately limit their ability to reach their full linguistic potential (Botes et al., 2020; Fondo et al., 2018; Vo et al., 2017), it remains imperative to continue researching how FLA may be alleviated for language learners.

Factors that Influence Anxiety

Research has shown that some learners are more prone to experiencing FLA than others and subsequent studies have sought to explore what factors impact FLA (Aida, 1994; Allen & Herron, 2003; Dewaele et al., 2016; Dewaele & Alfawzan, 2018; Dewaele & MacIntyre, 2014; Dewey et al., 2018; MacIntyre et. al., 2002; Zhang, 2019). Specifically, it has been argued that individual differences (i.e., language background, personality type, age, gender, etc.) and context (i.e., learning environment, type of interactions) can impact FLA.

Language background has been found to play a role in the extent to which language learners experience FLA. For example, it has been found that the number of languages previously learned impacts FLA, and that multilingual learners -- particularly of typologically similar languages -- typically have lower anxiety (Dewaele & MacIntyre, 2014). Furthermore, learners who have spent time abroad often exhibit lower FLA as well (Allen & Herron, 2003). Yet, while it might seem that learners with more advanced language skills would experience lower FLA, studies that have examined the relationship between foreign language proficiency and FLA have yielded mixed results. On the one hand, foreign language proficiency level and perceived foreign language ability have been found to negatively correlate with FLA (Dewaele & Alfawzan, 2018; Dewaele & MacIntyre, 2014; Dewey et al., 2018; MacIntyre et. al., 2002). However, a recent meta-analysis conducted by Zhang (2019) found that proficiency level did not impact FLA and, rather, that advanced learners may still experience high anxiety. Indeed, it appears that learners perceived-competency (i.e., if they think of themselves as competent L2 speakers) impacts FLA greater than actual linguistic-competency (Dewaele & MacIntyre, 2014; MacIntyre et al., 2002). Additionally, some have argued that FLA can develop as a result of negative experiences that students may have had while learning and using the language (Aida, 1994; MacIntyre & Gardner, 1991). Lastly, some studies have found that learners with high language learning strategies experience less FLA (Biria, 2013).

Individual differences (i.e., personality type, age, and gender) have also been found to impact FLA. Personality differences (e.g., being extraverted vs. introverted) can lead to differences in FLA and willingness to communicate in language learners, with more extraverted students usually experiencing lower FLA (Dewaele et al., 2016; Dewey et al., 2018; MacIntyre et. al., 2002). Moreover, personality dimensions such a perfectionism and neuroticism have been found to negatively correlate with FLA (Dewaele, 2013). Furthermore, gender has been found to play a complex role in FLA. Specifically, several studies have found female learners to report higher anxiety than male learners (Aida, 1994; Amiri & Ghonsooly, 2015; Dewaele & MacIntyre, 2014; Dewaele et al., 2016). However, while Dewaele et al. (2016) found female students to report higher anxiety and lower self-confidence (see also, Botes et al., 2020; Dewaele, 2013), they found no gender differences regarding physical responses to anxiety (e.g., starting to panic). Age has also been found to impact FLA, however results from studies thus far have been conflicting (Botes et al., 2020). Indeed, in their 2014 study, Deweale and MacIntyre concluded that older learners experience lower anxiety after finding that teenagers exhibited the highest levels of FLA, followed by those in their twenties. However, Zhang (2019) found that older learners were more anxious than younger ones. Finally, regarding the importance of research on how age and gender impact anxiety, MacIntyre et al. (2002) argue that:

> "If the goal of L2 instruction is to increase the use of the L2, especially outside of the classroom, our understanding of age and sex variations becomes of paramount importance. L2 communication is a context-bound phenomenon, and that context is heavily determined by fundamental characteristics of the learner" (p. 560).

Along with individual differences, it has also been argued that learners' FLA might stem from various fears. Specifically, research has found that fear of performing in front of others, fear of negative evaluation (particularly from peers), negative self-evaluation and fear of failing, discomfort towards speaking with native speakers, fear of being called on in class and speaking without preparation, and discussing unfamiliar topics can all lead to FLA (Aida, 1994; Aslan & Sahin, 2020; Boudreau et al., 2020; Dewaele & Dewaele, 2017; Fondo et al., 2018; Ipek, 2016; Khoroshilova, 2016; Maria-Signona & Barros-Del Rio, 2016; Shirvan & Talebzadeh, 2020; Vo et al., 2017; Zheng & Cheng, 2018). Furthermore, it has repeatedly been found that oral production tasks are the most anxiety-provoking for language learners (Boudreau et al., 2020; Ipek, 2016; MacIntyre & Gardner, 1994b; Teimouri et al., 2019).

Given the scope of these various contributing factors, it has been argued that FLA research must consider learners' full ecosystems in order to truly understand how FLA impacts learning (Mahmoodzadeh & Gkonou, 2015; Saghafi et al., 2017; Shirvan et al., 2020). Specifically, it has been argued that a learner's ecosystem can be broken into four smaller sub-systems: the (1) micro-system, (2) meso-system, (3) exo-system, and (4) macro-system (Shirvan et al., 2020). Factors contributing to anxiety at the micro-level could be learner beliefs and motivation or linguistic knowledge, whereas factors at the meso-level could be extracurricular activities like watching TV in English. Furthermore, factors at the exo-level could be the design of the course and curriculum, whereas factors at the macro-level could be a learners' cultural and moral beliefs (Saghafi et al., 2017; Shirvan et al., 2020). It has been argued that researchers should try to account for as many of these systems as possible and examine how they interact synergistically and change over time in order to begin to understand the complex relationship between FLA and learning (Mahmoodzadeh & Gkonou, 2015; Sagahafi et al., 2017; Shirvan et al., 2020).

Anxiety and Generation Z

Regarding the notion of age and FLA, it is important to note that the students in the current study are part of Generation Z (i.e., born between 1995 and 2010) (Seemiller, 2017). These students are different from previous generations in that they are considered digital natives that “do not [even] know a world without personal digital devices like smartphones and tablets” (Seemiller, 2017, p. 5).

In terms of learning and communication, it has been found that this generation embraces independent learning and using the internet to help them (Seemiller & Grace, 2019). However, it has been suggested that this preference for independent learning stems from their fear of providing the wrong answer in class and being judged by their peers and instructor. (Seemiller, 2017; Seemiller & Grace, 2019). Moreover, when in a learning environment perceived as low-risk, Generation Z students have been found to prefer group work and hands-on experiential, learning activities where they can immediately see a connection between what they are doing in class and real life (Seemiller & Grace, 2017 & 2019). However, although Gen-Z students rely heavily on their smartphones and personal technology, 83% of them report that they prefer face-to-face communication (Seemiller & Grace, 2016 & 2019), probably to be able to have access to both verbal and nonverbal cues.

Concerning anxiety, it has been found that Generation Z has “the highest rate of diagnosed depression followed by anxiety” of any generation (Schroth, 2019; see also, Seemiller & Grace, 2019). Indeed, an overwhelming 95% of Gen Z students reported that they frequently or occasionally feel stressed and anxious, and “more than 51 percent of college seniors report having average or below average levels of social self-confidence” (Seemiller & Grace, 2019, p. 97). Moreover, it has been found that on a scale from one-to-ten, Gen Z ranks at a 5.3 in terms of stress, compared to a 5.1 for Gen X, a 4.1 for Boomers, and a 3.3 for older generations (American Psychological Association, 2018). While some of this anxiety is due to the environment in which they grew up, Gen Z students are also particularly concerned about how their classmates and teachers perceive them, which can lead to heightened anxiety during class time (Seemiller & Grace, 2019). As general social anxiety and FLA are considered to be connected, these students could be particularly prone to higher FLA. Indeed, Dewaele and MacIntyre (2014) and Zhang (2019) both found that those with the highest FLA also belong to Gen Z. Consequently, as research has shown that FLA is detrimental to language learning achievement and that Gen Z students are more prone to it, it is imperative that scholars continue to research ways to alleviate it in learners.

Anxiety and the Environment

FLA research has passed through three main stages, or approaches: (1) the confounded approach, (2) the specialized approach, and, recently, (3) the dynamic approach (MacIntyre, 2017). Research studies that adopted the *confounded* approach examined “ideas regarding language anxiety as well as its influence on learning a foreign or second language from an amalgamation of numerous resources, which are [were] not necessarily associated with language learning” (Saghafi & Shirvan, 2020, p. 83; see also, MacIntyre, 2017). Conversely, the *specialized* approach towards FLA research aimed to explore and identify incidences of anxiety that were specifically related to language learning (MacIntyre, 2017; Saghafi & Shirvan, 2020).

However, more recently, scholars have argued for adopting a dynamic approach to anxiety (Dewaele & Alfawzan, 2018; Dewey et al., 2018; Gkonou et al., 2017; Gregerson et al., 2014; Kasbi & Shirvan, 2017; MacIntyre, 2017, MacIntyre & Vincze, 2017; Saghafi & Shirvan, 2020; Sampson, 2019; Shirvan & Talebzadeh, 2017 & 2020). Indeed, Dewaele & Alfawzan (2018) explain that around 2010, FLA research entered a new, third stage: "The Dynamic Approach, [...] whose principal aim is to situate anxiety among a range of interacting factors that affect acquisition of the FL and performance in the FL. Anxiety […] is constantly fluctuating over different timescales [e.g., minutes or seconds]" (p. 24; see also, MacIntyre, 2017; Saghafi & Shirvan, 2020; Shirvan & Taherian, 2018). One of these key factors that must be considered is the learning environment or context, as learners can be impacted by environmental factors such as the environment itself, behavior of their teachers or classmates, the constraints of classroom accessibility, and their familiarity with technology if it is being used (Shirvan & Taherian, 2018). Indeed, Gkonou et al., (2017) noted that:

> "there is much to recommend the recent focus of the dynamics of language anxiety. One lesson that emerges emphasizes the importance of the context, not only the interpersonal and social context of the surrounding environment but also the physiological context of the learner, including physiological and emotional processes. Dynamic studies emphasize the complex interactions of multiple factors that influence the anxiety reaction, including […] the features of the learning/communication situation" (p. 26).

In other words, learners are highly impacted by the environment in which they are learning, with Gregersen et al. (2014) arguing that the "brain's continuous evaluation of the environment around us sets the foundation for emotional responses to language learning" (p. 575).

A particularly important environmental factor in the current study was the on-going COVID-19 pandemic. The pandemic drastically changed the type of learning environments available for students, as most learning had to take place virtually at a distance for safety concerns. This emergency transition to online learning that had to take place without proper training and preparation could also have changed students' perceptions towards technology and how they feel it benefits or detracts from their learning. Moreover, given the added stress of COVID-19, it can be hypothesized that learners' general anxiety and stress would be heightened during this time and that this could impact how they responded to the different activities (Elshami et al., 2021).

Anxiety and Oral Production

Having to speak in a foreign language has been found to be a primary source of FLA for learners, more so than any other skill (Boudreau et al., 2020; Dewaele, 2013; Ipek, 2016; MacIntyre & Gardner, 1994b; Mahmoodzadeh & Gkonou, 2015; Signona & Barros-Del Rio, 2016; Teimouri et al., 2019). Moreover, anxiety has been found to negatively impact learners' oral production, not only because learners typically speak less when anxious, but also because anxiety impacts pronunciation itself (Feigenbaum, 2007; Khoroshilova, 2016; Szyszka, 2017). Indeed, Szyszka (2017) showed that anxiety causes dysfluency and negatively impacts pronunciation, since anxiousness "results in muscle tension, so the speech organs that should be flexible for clear pronunciation become tense, limiting the articulatory potential of the speaker" (p. 52). Consequently, "a high level of anxiety may lead to neuromuscular problems with sounds.

[…] Therefore, the process of sound articulation may be affected by muscle tension causing changes in pronunciation" (p. 53; see also, Khoroshilova, 2016). Furthermore, it has been shown that the neural mechanisms underlying L2 communication are sensitive to anxiety, in that anxiety inhibits appropriate neural responses and can negatively impact fluency (Jeong et al., 2014).

It can be argued that learners' comprehensibility and intelligibility could be negatively impacted by high anxiety, since both rely primarily on pronunciation. While *comprehensibility* refers to the amount of "effort listeners expend in understand utterances" (Thomson, 2018, p. 5), *intelligibility* refers to "the extent to which a speaker's message is actually understood" (Munro & Derwing, 1995a, 1995b, as cited in Thomson, 2018, p. 4). Moreover, previous research has found that language learners' levels of intelligibility and comprehensibility are often related (Derwing & Munro, 1997). For the purpose of this study, *fluency* is defined as "the degree to which speech flows easily without pauses and other dysfluency markers" (Derwing & Munro, 2015, p. 177).

Several studies have indeed found anxiety to negatively impact learner performance and fluency. For example, anxiety has been found to negatively correlate with oral exam scores in learners, even when taking into account language aptitude (Aida, 1994). MacIntyre and Gardner (1994a) also found that anxiety negatively impacted the quality of language produced in L2 French learners. Moreover, Sanaei et al.'s (2015) study examining the impact of FLA on 11 intermediate EFL learner's oral narrative fluency indicated that low anxiety correlated positively with fluency, while higher anxiety led to more fluency breakdowns. The researchers concluded that students who felt less anxious were able to produce more grammatically accurate and fluent speech. Castillejo (2019) also examined the impact of anxiety on 38 students' L2 Spanish utterance fluency and found anxiety to be a strong predictor of certain temporal features associated with subjective ratings of fluency while proficiency was not. Moreover, it has also been argued that anxiety also negatively impacts fluency by preventing students from taking risks in the language and lowering willingness to communicate and overall language production (MacIntyre & Gardner, 1994b).

Although several studies have examined the impact of anxiety on performance, Zhang (2019) calls for additional research, stating that “it is worth emphasizing that the emotional aspect of language acquisition plays an indispensable role in FL learning [...]; a better understanding of the anxiety-performance relationship is beneficial to FLA learning. After all, performance is one of the most important outcomes of FL learning” (p. 776). Specifically, more research is needed that examines more advanced language learners’ oral fluency in languages other than English and in interpersonal tasks (Burston & Arispe, 2018; Huensch & Nagle, 2021). Indeed, Burston and Arispe (2018) call for current research to “increase the number of languages targeted and [...] [to] include a much larger proportion of aural-oral skills” (p. 95). Finally, there has also been a call to examine factors that lead to emerging moments of anxiety during interpersonal communicative tasks specifically during class time and not in an artificial research lab (Kasbi & Shirvan, 2017; Sampson, 2019; Shirvan & Talebzadeh, 2017). The present study therefore aimed to address these research gaps by a) examining whether and how lower anxiety impacted comprehensibility, intelligibility, fluency, and b) documenting and analyzing participants’ unfolding conversational interactions and moments of emerging anxiety in the realistic setting of the course they were all enrolled in.

Evaluating Anxiety

Measuring anxiety can either be done explicitly (i.e., through self-assessment questionnaires) or implicitly (i.e., through physiological measures such as heart rate (HR), skin conductance, and cortisol levels). While explicit measures can be seen as measuring learners' experiential responses or what they perceive to be feeling, implicit measures can capture learners' internal physical changes in response to anxiety (Meer et al., 2016). Therefore, self-reported data reflects the conscious evaluation of anxiety, while physiological measures can be viewed as being much more under the control of non-conscious automatic processes (Gregersen et al., 2014). Moreover, it has been argued "dynamic and simultaneous physiological measures [such as HR] provide a unique framework for understanding emotion and cognition that cannot be provided by static measures like self-reports" (Meer et al., 2016).

Thus far, the majority of research conducted on foreign language anxiety has been done explicitly through self-reported questionnaires, interviews, or diaries (Gregersen et al., 2014). However, scholars have recently been pushing for complementing self-reported data with more implicit, objective physiological measures in FLA research (Teimouri et al., 2019). Indeed, adding physiological measurements such as HR would enable researchers to study anxiety dynamically second-by-second by examining how and when HR increases and/or decreases throughout a task (Gregersen et al., 2014; Kasbi & Shirvan, 2017; Sampson, 2019; Shirvan & Taherian, 2018). Moreover, it has been found that HR and self-reported anxiety data correlate poorly (Clarke et al., 2014; Meer et al., 2016), suggesting that they measure two different facets of anxiety (i.e., what a learner feels and what is physically happening in the body) that could both be valuable when trying to understand how FLA fluctuates across various learning environments.

However, the push for the inclusion of physiological measures in FLA research is not new. In fact, in his review paper on FLA anxiety research, Scoval argued as early as 1978 that, in psychology, "physiological measures have long been used as an easily quantifiable indicator of a subject's emotional state" (p. 135). Indeed Scoval (1978) specifically called for examining the relationship between "physiological measures of emotional arousal and success in foreign language performance, especially in articulatory tasks" (p. 135). However, few studies on FLA have followed suit and included physiological measures (Dewey et al., 2018; Gregersen et al., 2014; Gruber & Kaplan-Rakowski, 2021; Korpal, 2016) and even fewer have examined the relationship between these measures and oral production tasks (Gregersen et al., 2014; Gruber & Kaplan-Rakowski, 2021; Korpal, 2016). In 2014, Gregersen et al. employed HR measures while examining how anxiety fluctuated for L2 Spanish learners but did so in presentational rather than interpersonal oral tasks. Likewise, Korpal (2016) examined how students' HR fluctuated during simultaneous interpreting activities and found that HR increased when students were required to interpret faster. Finally, Gruber & Kaplan-Rakowski (2021) have measured anxiety levels through HR and electrodermal activity readings of students speaking their L2 in a VR environment. However, this work is still on-going, and no results have been drawn.

The lack of research in this area led Boudreau et al. (2018) to conclude that "further analysis of physiological data such as heart rate [...] in conjunction with [...] qualitative interview data could lead to a more complete understanding of participants' emotional reactions" (p. 166). Therefore, this study intends to contribute to this limited body of research by evaluating L2 French learners' anxiety using both self-reported questionnaires and heart rate during interpersonal speaking tasks in a traditional classroom, *Zoom*, and VR. It will also merge these results with qualitative findings from semi-structured interviews conducted with participants in order to develop a more complete understanding of learners' emotional responses to the various learning environments.

Virtual Environments and Language Learning

There is a plethora of different types of virtual technologies that have been used for language learning and teaching, including personal computer programs with drill-based learning activities, cellphones, social networks (e.g., Facebook, Instagram), video conferencing platforms (e.g., Skype, Zoom), course management systems (e.g., Moodle, Blackboard), virtual worlds (e.g., Second Life), and virtual realities (e.g., vTime XR, Altspace) (Mroz, 2014). With technology so interwoven in today's society, the use of these virtual environments for language learning has becoming more pervasive that it is simply not possible to ignore how commonplace they have become (Chun et al., 2016). This has only been furthered by the on-going COVID-19 pandemic, which forced the vast majority of language instruction to occur virtually from Spring 2020-Fall 2021. That being said, it is important to research and understand how learners respond to these types of environments in comparison to traditional face-to-face classrooms to ensure that they are being used in an effective manner that will benefit the language learning process.

Different types of virtual environments offer various *affordances*, which can be defined as the "potential a particular property of the environment [or technology] has to contribute to actions carried out by a learner in the environment, but this property does not in and of itself cause or trigger action unless it is perceived as relevant and activated by this learner" (Mroz, 2015, p. 532). For example, an affordance of VR could be that it reduces distractions by closing a learner off to the outside world, but only if the learner themselves actually finds this to be true. This study explores the affordances that language learners perceived as beneficial or detrimental for their language learning of both video-conferencing platforms and VR.

Various virtual environments also lead to varying degrees of *presence* or immersion. Presence has been defined as "the psychological experience of 'being there,' or the experience of being in one environment when the person is physically in another" (Parong et al., 2021, p. 2). A higher degree of presence has been found to lead to a higher degree of immersion, which can enhance social learning and benefit language learning (Lan et al., 2015; Liu et al., 2017). Indeed, Lan (2020) argues that the higher presence afforded by fully-immersive VR systems can lead to three key factors: immersion, creation, and interaction. Lan (2020) further explains that these three factors mirror four characteristics of successful language learning: immersion, participation, interaction, authenticity.

Moreover, high-immersion technology (e.g., fully-immersive VR systems) typically induce a stronger sense of presence than low-immersion technology (e.g., virtual environments accessed via a computer screen). This is not surprising, as high-immersion VR systems fully envelope users' vision and make it seem as though they are actually physically in the virtual environment. Furthermore, the use of avatars has been found to increase presence (Petersen, 2011), since users can perceive them as extended versions of themselves. Lastly, when convincing, this presence stemming from both 360° environments and avatars can lead to a "suspension of disbelief" where learners actually feel as though they are truly in the VR space despite knowing that they are not. The current study explores whether the stronger degree of presence afforded by VR actually benefited language learners' interactions.

Video-Conferencing Platforms

Video conferencing is an online technology accessed via an internet connection on a computer or smartphone that allows users in different locations to hear and see each other and hold face-to-face meetings without having to be physically together (Eaton, 2010). Two of the most common video-conferencing platforms that exist and that have been used in foreign language research are *Skype* and *Zoom* (Figure 1). One thing that sets video conferencing platforms apart from the *vTimeXR* VR platform is the fact that users can see each other's real faces and also can decide to turn their microphones off and on throughout the meeting.

Figure 1. Learners using Zoom

According to the company Zoom Video Communications, *Zoom* is a “secure, reliable video platform [that] powers all of your communication needs, including meetings, chat, phone, webinars, and online events” (2021, n.p.). *Zoom* is particularly relevant to the current study, as it experienced an explosion in popularity at the onset of the COVID-19 pandemic, with most universities turning to the platform as a solution for delivering course content online to students. Moreover, even prior to COVID-19, language departments have been increasingly pushed to offer online language classes using these platforms, though their efficacy has not been sufficiently researched (Tecedor & Campos-Ditrans, 2019). Given this heighted relevance of video-conferencing platforms, the current study sought to evaluate whether and how completing speaking tasks on *Zoom* impacted participants’ anxiety and language performance compared to a traditional classroom and VR.

Previous research has noted several potential affordances of video-conferencing platforms for language learning, including the ability for learners to develop intercultural competence and speaking skills via cross-cultural exchanges (Fondo et al., 2018; Tecedor & Campos-Ditrans, 2019). In light of the COVID-19 pandemic, a major advantage of video-conferencing platforms is that they allow users to virtually see, hear, and communicate with each other when they are not able to be physically together. That being said, it could be argued that video-conferencing platforms, although still a virtual medium of instruction, can simulate face-to-face conversations and could consequently lead to an increase in FLA.

The few studies that have examined whether video-conferencing platforms can reduce FLA compared to traditional face-to-face classrooms have yielded mixed results (Punar & Uzun, 2019; Terantino, 2014; York et al., 2021). Indeed, Punar and Uzun (2019) had 21 EFL learners (N = 21) complete speaking activities on either Skype (n = 11) or face-to-face in a traditional classroom (n = 10). Their results showed that FLA significantly decreased for learners who completed tasks on Skype, but not for those who did so in the classroom, leading the authors to conclude that video-conferencing platforms could be beneficial for FLA. However, Terantino (2014) examined whether oral assessments administered face-to-face compared to on Skype impacted the FLA of 81 (N = 81) Russian language learners and found no difference between the two delivery methods. Moreover, in a study comparing the FLA levels of 30 EFL learners (N = 30) during voice-chat, video-chat, and VR activities, York et al. (2021)'s qualitative data revealed that some participants found that video conferencing increased anxiety, since they felt uncomfortable being seen on camera by others (York et al., 2021). Furthermore, in light of the rise in popularity of *Zoom* during the COVID-19 pandemic, it could also be expected that learners' perceptions towards *Zoom* might have evolved, as they have become much more accustomed to using this platform in their daily lives. Given this and the mixed results of previous research, the current study aimed to examine whether conversing on *Zoom* impacted learners' FLA, while also considering how the COVID-19 pandemic might have influenced participants' perceptions of video-conferencing platforms.

Virtual Worlds

Virtual *worlds* (VWs) have been defined as "realistic and immersive contexts" accessed typically via a desktop computer or two-dimensional monitor that "enable real-time communication" between users (Peterson, 2011, pp. 68-69; see also, Sadler, 2017 & 2019 & Qiu et al., 2021). Perhaps the most widely known VW amongst CALL researchers is *Second Life* -- a platform that allows learners to create their own virtual-selves (i.e., avatars) that they then use to explore locations and interact within the VW (Sadler 2017 & 2019). Specifically, these VWs let users "create a personal identity, enter into relationships, negotiate common rules of social conduct, and accomplish collaborative action all through language", while also "fabricat[ing] a reality that stimulates the imagination and transcends the actual reality of individuals sitting in front of keyboards and luminescent screens (Chun et al., 2016, p. 96). Taken together, all these affordances of VWs create a social, authentic language learning environment, without which language learning is meaningless (Qiu et al., 2021).

Numerous CALL researchers have explored using VWs for language learning (Chun et al., 2016; Liu et al., 2017; Mroz, 2015; Sadler, 2017 & 2019; Parmaxi, 2020; Peterson, 2011; Qiu et al., 2021; Wigham et al., 2018), and the vast majority of CALL research conducted on virtual environments has been done within VWs (Parmaxi, 2020; Qiu et al., 2021). Indeed, in a recent meta-analysis with 150 studies on VWs and realities in language learning, Qiu et al. (2021) found that research on VWs experienced a surge between the years of 2008-2016, with the vast majority of work being conducted with English language learners. Parmaxi (2020) found similar results in his meta-analysis reviewing 26 empirical studies conducted and published in virtual environments from 2015-2018. Specifically, he found that 20/26 studies were done using some type of VW (15/26 using Second Life and 5/26 using other VWs), and that most studies were with English learners. Both meta-analyses reported only 1 study looking at French learners in VWs (Mroz, 2015) and very few studies -- 1 for Parmaxi (2020) and 9 for Qiu et al. (2021) -- using more advanced fully immersive VR technology. This is not surprising, as fully immersive VR technology has only become more accessible to researchers and students in recent years. However, given the very limited research conducted on French language learners in virtual environments, this study examined how VR impacted French language learners' anxiety and performance in French.

CALL scholars have noted several benefits of using VWs for language learning, including enhanced social learning and social immersion, situated learning that leads to higher transfer of knowledge, and the ability to create interactions and activities not possible in the real world (Lan et al., 2015; Liu et al., 2017, Sadler 2017 & 2019). Furthermore, research has found that VWs have a positive effect on learners' affective filters (e.g., reducing anxiety and increasing motivation and willingness to communicate) (Melchor-Coutu 2016 & 2018; Mroz, 2015; Reinders & Wattana, 2014; Wehner et al., 2011) and social interactions (Kruk, 2019; Wigham et al., 2018). It has largely been argued that the lower anxiety afforded by VWs can be attributed to the anonymity provided by avatars, as learners often feel more shielded from others when interacting in these virtual spaces (Melchor-Coutu 2016 & 2018; Mroz, 2015; Peterson, 2011; Reinders & Wattana, 2014; Wehner et al., 2011). Furthermore, it has been noted that this lower anxiety can, in turn, encourage learners to take risks and engage in language play, increase embodiment and presence, and foster emotional investment that leads to participation, motivation and increased linguistic output (Peterson, 2011).

Despite the promising research showing that VWs can alleviate FLA, it remains unknown whether learners will experience similar benefits when interacting in fully immersive VR environments, given the scarcity of research in this domain (Parmaxi, 2020; Qiu et al., 2021). Moreover, there has also been a gap in research that considers the complexity of learning in these environments and students' communication patterns during group work (Lan et al., 2015; Wigham et al., 2018). Given this, the current study examined whether VR can also lead to lower FLA and explored how students interact with their peers during group consensus-building tasks.

Virtual Reality

Research on virtual *realities* and language learning has been increasing as VR headsets become more commonplace and readily affordable (Huang et al., 2021; Peixoto et al., 2021). Indeed, 5.5 million VR headsets were shipped around the world in 2020 and it is predicted that 43.5 million headsets will be bought each year by 2025 (XR Today, 2021). It is also predicted that the field of education will experience a 28% growth in VR usage by 2024 (XR Today, 2021), making research that examines how VR can best be integrated into classrooms imperative (Huang et al., 2021).

VR involves wearing a headset that "produce[s] a 3D virtual world, [...] with visual, auditory, and tactile sensory simulations [...] that enables real-time, unrestricted [first person] observation [...] and allows for user interaction" (Tsai et al., 2018, p. 2; see also, Huang et al., 2021; Liu et al., 2017; Peixoto et al., 2021). VR experiences can be further divided into two distinct categories based on the quality of the VR headset being used: low-immersion VR (e.g., Google Cardboard) and high-immersion VR (Oculus Go or Oculus Quest), with high-immersion VR systems rendering a more authentic, fully immersive experience. Lastly, learners can use VR for a variety of experiences, ranging from viewing a 360º video or image pertaining to the target culture, to interacting one-on-one with an AI bot or computer (e.g., *Mondly* or *ImmerseMe*), and finally to interacting in real-time with other users within a social VR platform (e.g., *vTimeXR* or *AltSpaceVR*).

One major affordance of VR is its ability to fully-immerse learners in a virtual space. Indeed, these VR systems "fully envelope [users' vision], creating a sense of full immersion" that "offer[s] high quality experiential learning, going beyond traditional, passive teaching and learning environments and [...] engage[s] learners actively in multi-sensory digital learning ecosystems" (Parmaxi, 2020, pp. 6 & 11; see also, Liu et al., 2017; Parong et al., 2020). This level of full immersion is the main distinction between VR and VW environments like *Second Life* that only afford partial immersion via computer screens (O'Brien et al., 2008; Parong et al., 2020). Indeed, with VWs, users can still see the real world while having the virtual one projected on a screen in front of them. However, VR "headset[s] physically disconnect users from the real world, allowing for deeper immersion in [and exploration of] the virtual space" (Kaplan-Rakowski & Gruber, 2019, p. 2; see also, O'Brien et al., 2008). Figure 2 provides a screen capture of learners from the current study immersed in VR and Figure 3 shows a picture of a student wearing a VR headset.

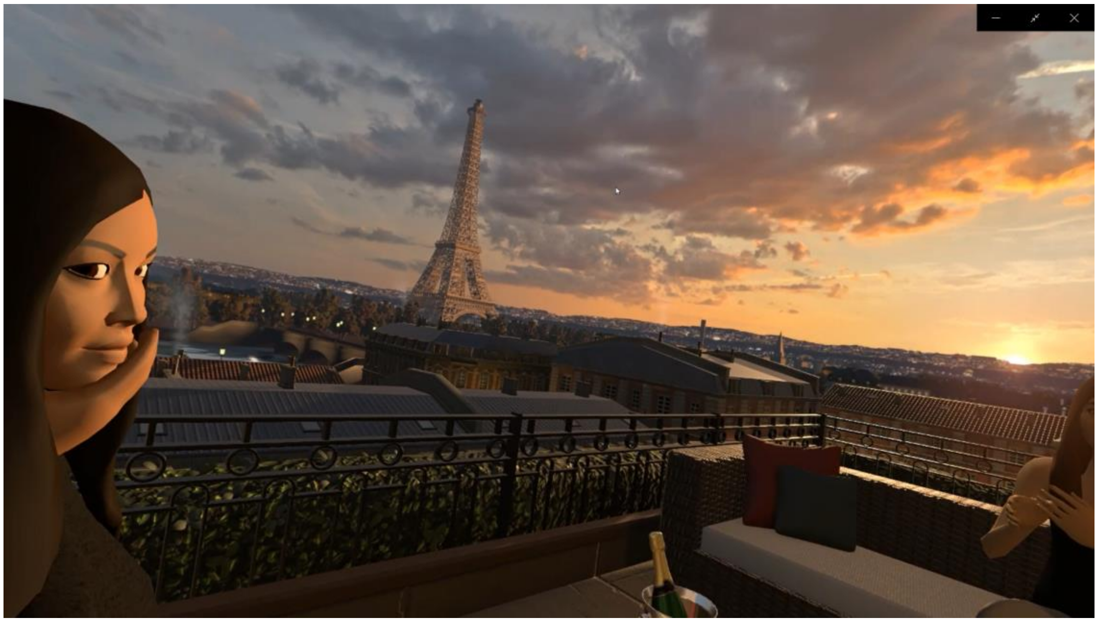


Figure 2. Learners immersed in *vTime XR* VR setting

Figure 3. Student wearing VR headset (Innes, 2019).

Full immersion via VR enables learners to explore authentic environments and participate in new experiences that are not possible in a typical classroom (Kessler, 2017; Lan, 2020;

O'Brien, 2008; Peixoto et al., 2021; Xie et al., 2019). Moreover, the loss of contact with the real world can induce a high degree of presence and immersion (Gruber & Kaplan-Rakowski, 2020; Lan, 2020; O'Brien, 2008; Parmaxi, 2020), which can in turn lead to higher levels of engagement, learning, and attention (Bonner & Reinders, 2018; Kaplan-Rakowski & Meseberg, 2018). Furthermore, this loss of contact with the real world can help attract learners' attention in an era when attention spans are limited (Alfahla, 2018; Seemiller & Grace, 2019).

In terms of language learning, CALL researchers have cited many benefits of using VR, notably:

- The ability to provide contextualized, culturally relevant learning (Christoforou et al., 2020; Huang et al., 2021)
- The possibility to transport students to places that they cannot physically visit (Chien et al., 2019; Liu et al., 2017; O' Brien, 2008; Parong et al., 2020)
- The opportunity to create L2 simulations for training purposes (Alfahla, 2018; Liu et al., 2017; Parong et al., 2020; Plutino et al., 2020)
- The ability to record the learning process for further analyses (Chien et al., 2019; Chun et al., 2016)
- The ability to create student-centered collaborative interactions (Alfahla, 2018; Bonner & Reinders, 2018; Liaw, 2019; O'Brien et al., 2008; Parmaxi, 2020)
- The beneficial impact on affective factors (e.g., motivation, enjoyment, anxiety) (Allcoat & Muhlenen, 2018; Chateau et al., 2019; Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Kaplan-Rakowski & Wojdynski, 2018; Liaw, 2019; O'Brien et al., 2008; Peixoto et al., 2021; Xie et al., 2019; York et al., 2021; Ziegler, 2016)

- Better vocabulary learning (Andujar & Buckner, 2019; Chen, 2016; Huang et al., 2021; O'Brien et al., 2008)
- Better listening skills (Chateau et al., 2019; O'Brien et al., 2008)
- Improved grammar (Chen, 2016; Chien et al., 2019)
- Better speaking skills (Huang et al., 2021; Parmaxi, 2020)
- Improved pronunciation (Chen, 2016; Chien et al., 2019; Huang et al., 2021)

VR and FLA

As with VWs, it has largely been hypothesized that learners could experience lower FLA in VR due to the use of avatars (Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Liaw, 2019; Xie et al., 2019; York et al., 2021). While these avatars shield users from being physically seen by others, and can at times provide anonymity, they also reduce social gestures and cues (e.g., eye contact) that can contribute to anxiety. Moreover, it has also been argued that students who experience higher FLA or social anxiety to begin with will be those who are most positively impacted by being immersed in these virtual environments compared to their lower anxiety peers (Handley, 2018), though this remains to be empirically tested (Huang et al., 2021).

Despite the increase in VR research, only a few studies have examined how VR impacts FLA in relation to speaking (Gruber & Kaplan-Rakowski, 2020 & 2021; Liaw, 2019; Xie et al., 2019; York et al., 2021). However, research thus far suggests a positive impact of VR on anxiety during speaking tasks. Indeed, Xie et al. (2019) had 12 L2 Chinese learners use Google Cardboard to give oral presentations of Chinese tourist attractions. Participants' qualitative feedback revealed that VR "ease[d] nervousness" during presentations (p. 255). Consequently, students also reported that they were able to speak more fluently, though this was not empirically measured using speech data. Liaw (2019) had 17 EFL learners use *vTime XR*™ to converse with English speakers around the world. Through open-ended questions, she found that learners felt less anxious when interacting via avatars. Gruber and Kaplan-Rakowski (2020) also explored how 12 participants thought VR impacted their public speaking anxiety when giving speeches in a foreign language to a simulated classroom audience. In semi-structured interviews, participants noted that VR can be useful for practicing presentations in a foreign language and that it can, therefore, alleviate anxiety. In a follow-up study, Gruber and Kaplan-Rakowski (2021) also found that students completing L2 public speaking tasks in VR had significantly lower anxiety than those completing them on *Zoom*. Finally, York et al. (2021) examined how 30 EFL learners' anxiety varied throughout oral spot-the-difference tasks in three different online environments: purely voice-audio, video call, and VR. Although the authors did not find any statistically significant differences in anxiety across the environments, participants self-reported lower anxiety in VR compared to video and voice calls.

Despite this promising recent work, more research examining VR and FLA is needed (York et al., 2021), since the studies thus far have focused solely on whether or not VR reduces FLA and have not "provid[ed] empirical evidence about whether these VR tools could improve students' oral proficiency in various aspects, such as pronunciation" (Xie et al., 2019, p. 257; see also, Ziegler, 2016). Moreover, there is also a need for work examining "more practical implementations [of VR] [...] in real-life classrooms [...] [and] collaborative virtual reality experiences [...] in order to understand patterns of collaboration in such environments" (Parmaxi, 2020, p. 11; see also, Andujar & Buckner, 2019; Lan, 2020; Liaw, 2019; Zheng et al., 2017). Furthermore, Lan et al. (2018) have also called specifically for cross-discipline research that adopts a psychological approach when examining how VR impacts interactions (Lan et al., 2018). Consequently, the current study aimed to fill these gaps in research by examining whether and how VR impacted participants' physiological and self-reported anxiety and L2 performance when collaborating on consensus-building tasks with their peers during class time.

Learners' Perceptions of VR

As research on VR and language learning is still in its infancy, many researchers have aimed to capture language learners' opinions of this emerging technology. In general, so far students have reported enjoying being able to use VR for language learning purposes, saying that they find the experience to be immersive (Huang et al., 2021; Kaplan-Rakowski & Meseberg, 2018; Kaplan-Rakowski & Wojdynski, 2018), interesting (Chateau et al., 2019; Kaplan-Rakowski & Wojdynski, 2018), fun and different (O'Brien & Levy, 2008; Huang et al., 2021; York et al., 2021). Specifically, in their study with 30 (N = 30) EFL learners, York et al. (2021) noted that learners considered communicating and expressing themselves in VR to be significantly easier than voice or video calls and that they found it to be enjoyable and effective for learning. Their participants also specifically pointed out the novelty of VR and said it was "fun" and "cool." Kaplan-Rakowski & Wojdynski (2018) reported similar findings in their study with 22 (N = 22) EFL learners. Indeed, their participants noted that they enjoyed and wanted to study languages using VR, that they found VR to be immersive, and that it helped them focus 100% on what they were doing by minimizing distractions.

However, participants have also pointed out the technological challenges that accompany using VR for language learning purposes. Specifically, users have noted that the technology does not always work well (Huang et al., 2021; Kaplan-Rakowski & Meseberg, 2018; O'Brien & Levy, 2008; Peterson, 2011; York et al., 2021), and that this can reduce their sense of presence (Roy, 2014) and motivation and participation (O'Brien & Levy, 2008; Peterson, 2011). Furthermore, participants have also complained about headsets being uncomfortable (Kaplan-

Rakowski & Meseberg, 2018; York et al., 2021), poor image quality (York et al., 2021), connection issues (Kaplan-Rakowski & Meseberg, 2018), headaches, tiredness of eyes, and cybersickness (Kaplan-Rakowski & Wojdynski, 2018). Moreover, Satar & Ozdener (2008) argued that although the lack of visual cues can reduce FLA for some language learners, it can also cause negotiation of meaning to take longer and to be more difficult for learners who have lower proficiency levels. For this reason, it should still be expected that some learners will prefer face-to-face communication due to being able to see and hear their partners more easily (York et al., 2021).

Given the rise in popularity of using VR for educational purposes (XR Today, 2021), it is imperative that research continues to capture learners' opinions of this technology in order to ensure that it is being used in a manner that favors students' learning. This study therefore gathered participants' feedback on using VR with the aim of understanding what properties of the VR environments contributed to and detracted from the learning experience.

Research Questions

Motivated by this previous work and the existing gaps in research, this study addressed five research questions.

1) Was there a relationship at the onset of the study between participant background in terms of gender, time abroad, onset age of learning French, previous languages learned, and immersive tendencies and (a) general foreign language anxiety and (b) social anxiety? Was there a relationship between (a) and (b)?

2) To what extent did the learning environment (classroom, *Zoom*, or VR) impact participants' a) self-reported anxiety and b) heart rate during unrehearsed spontaneous interpersonal oral production?

3) To what extent did the learning environment and participants’ anxiety impact their (a) comprehensibility, (b) intelligibility, and (c) fluency? What was the relationship between (a), (b), and (c)?

4) How did focus groups’ peer-to-peer interactions vary across learning environments? How did participants’ heart rate fluctuate within a task in response to an unfolding interaction?

5) How did learners perceive the three learning environments?

CHAPTER 3: METHODOLOGY

Outline of Chapter

The goal of this chapter is to provide a detailed account of the methods used for this research study. The chapter begins with an overview of the pilot study (i.e., research questions, study design, analyses, main results, and limitations) that was conducted prior to the current study. Then, changes to the current study that were implemented based on the pilot study and the on-going COVID-19 pandemic are discussed. Next, the methods for the current study are presented as follows: (1) purpose and research questions, (2) participants, (3) overview of the study design, (4) data collection procedure, and (5) data analysis. The data collection procedure is broken into three phases: the pre-intervention phase (i.e., what participants did before the study tasks), the intervention phase (i.e., what participants did during the study tasks), and the post-intervention phase (i.e., what participants did after the study tasks). All questionnaires and materials used during the current study are presented as Appendices.

Pilot Study

Purpose of the Pilot Study

The pilot study addressed four research questions (RQs):

1) Was there a relationship at the onset of the study between participant background in terms of age, gender, time abroad, and onset age of learning French and (a) general foreign language anxiety and (b) social anxiety?
2) What was the impact of the learning environment (i.e., classroom vs. VR) on participants' a) self-reported anxiety and b) anxiety assessed via physiological measures (i.e., HR and salivary cortisol) during unrehearsed spontaneous interpersonal oral production? (c) What is the relationship between participants' self-reported anxiety measures and their physiological measures?

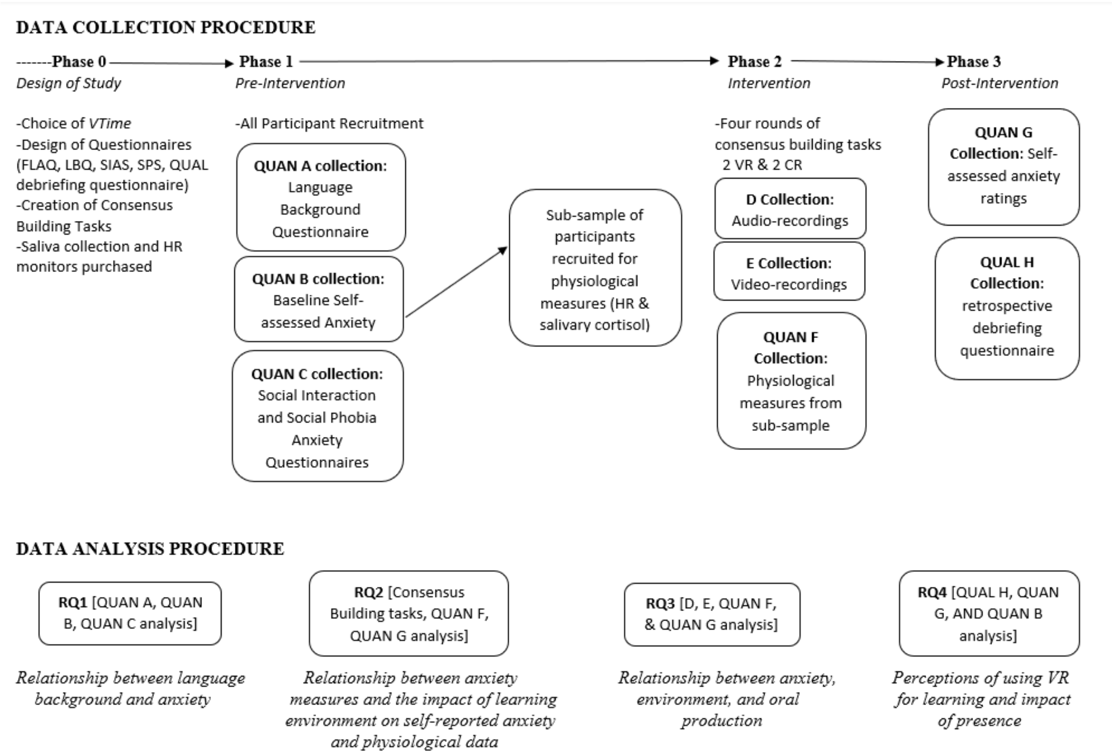
3) What was the relationship between the learning environment, participants' self-reported anxiety levels and their phonological (a) comprehensibility, (b) intelligibility, and (c) fluency? What is the relationship between (a), (b), and (c)?
4) How did participants perceive the impact of virtual reality on their language learning process? Was there a relationship between presence experienced in VR and participants' self-reported anxiety scores? How did being in a virtual environment impact participants' interactions with their peers?

The purpose of the pilot study was to conduct an alpha-test of the *vTime XR* virtual reality platform, the Oculus Rift S VR equipment, the Polar OH1 heartrate monitors, the methods for salivary cortisol collection, and all questionnaires being used in the current study. Data collection took place during the Fall 2019 and Spring 2020 semesters. During the study, all participants were enrolled in an Oral French course and were instructed by the same native French speaker three times a week for 50-minute class periods.

The Oral French course specifically aimed to help students "develop Intermediate-High / Advanced-Low [French] proficiency in communicated oral expression, listening comprehension, and cultural understanding," as stated in its syllabus. Students with Advanced-Low French proficiency can "participate in most informal and some formal conversations on topics related to school, home, and leisure activities," "narrate and describe in the major time frames of past, present, and future" and "handle appropriately the essential linguistic challenges presented by a complication or unexpected turn of events" (ACTFL, 2012, p. 6). Students with Intermediate-High proficiency can also accomplish these linguistic tasks *most* of the time. However, they are unable to consistently sustain this performance. To help students reach Advanced-Low / Intermediate-High proficiency, the course exposed students to a variety of authentic resources centered around 8 themes (e.g., (1) regions of France and the Francophone world, (2) trends and the youth, (3) science and technology, (4) ecology and the environment, (5) education, (6) sports and hobbies, (7) media, and (8) art and culture). A typical class session consisted of students watching videos related to the themes beforehand and then engaging in peer-to-peer and group discussions during class time. Students from this course were therefore chosen as participants for the current study, as they had practice narrating in various tenses, comparing and contrasting, and giving their opinion on a variety of topics.

Overview of Pilot Study Design & Participants

The pilot study adopted an *embedded* mixed methods design, which "involves the collection and analysis of both quantitative and qualitative data […] [where] one data set provides a supportive, secondary role" (Creswell & Plano Clark, 2011, p. 91). The purpose of using an *embedded* mixed methods design was twofold: (1) using solely quantitative data was not sufficient, as "each type of [research] question requires different types of data" and (2) qualitative data was specifically needed to help explain the quantitative results (Creswell & Plano Clark, 2011, p. 91). Specifically, this study relied on qualitative data to "give voice" to the learners, as "too much information is lost, especially in […] CALL, if the research relies solely on one particular approach" (Levy, 2015, p. 565). Figure 4 presents an overview of the methodology and design for the pilot study.



Key: FLAQ = foreign language anxiety questionnaire; LBQ = language background questionnaire; SIAS = social interaction anxiety scale; SPS = social phobia scale; QUAL = qualitative; HR = heart rate; QUAN = quantitative; VR = virtual reality; CR = classroom
Figure 4. Overview of pilot study design

After obtaining IRB approval, participants were recruited. Striving to respond to the lack of research on non-beginner learners of non-English languages in virtual environments (Burston & Arispe, 2018; Qiu et al., 2021), this study targeted intermediate learners of French as a foreign language. As data collection took place over two semesters, 27 (*n* = 27) participants were invited to participate in the study in Fall 2019 and 13 (*n* = 13) were invited in Spring 2020, with 25 (*n* = 25) students consenting to participate in the study during Fall 2019 and 13 (n = 13) students consenting during Spring 2020, (*N* = 38). As the study was integrated into an existing French course offered on campus, some participants were absent from one or more sessions of data collection. Therefore, in Fall 2019, 13 (*n* =13) participants attended all data collection sessions and in Spring 2020, 8 participants (*n* = 8) completed all sessions.

Next, participants' background and baseline self-reported anxiety (BA) were established, based on which the sub-sample of 18 participants (n = 18, 12 for Fall 2019, 6 for Spring 2020), later assigned to provide physiological measures, was recruited. Participants' baseline self-reported anxiety scores were used to establish this subsample in order to target those who reported either above or below-average self-reported anxiety. 9 participants were classified as ANX+ (i.e., having above the mean average for self-reported FLA), while 9 were classified as ANX– (i.e., having below the mean average for self-reported FLA). In Fall 2019, half of the subsample (n = 6) provided heart rate (HR) data and half (n = 6) provided saliva samples to test for salivary cortisol level. For the Spring 2020, all participants provided HR data. However, salivary cortisol was collected only from a sub-sample of 6 (n = 6) participants.

The intervention then consisted of four rounds of comparable three-way peer-to-peer interpersonal consensus building tasks (Inspired by Mroz (2012)) in French over an 8-week period in two different learning environments: two tasks in a classroom-based environment (CR) and two in a virtual reality (VR) environment. During the Fall 2019, all four tasks were audio-recorded, and VR tasks were additionally video-recorded. During the Spring 2020, tasks were both audio and video recorded. Moreover, physiological data (i.e., HR and saliva samples) were collected during each task from the sub-sample of ANX+ and ANX– participants.

Following each task, participants completed a short questionnaire to assess their self-reported anxiety level during the task (Figure 5). At the end of the study after completing all tasks, participants also answered an open-ended questionnaire to explore their perceptions of VR and its influence on their anxiety and learning (Figure 6).

1. Please enter your UIN. ______________________________

Please answer the following questions by providing the number corresponding to the option that best describes your opinion.

1 - Strongly Disagree
2 - Disagree
3 - Neither Agree nor Disagree
4 - Agree
5 - Strongly Agree

2. I felt at ease when completing this activity.	1	2	3	4	5
3. I didn't worry about making mistakes during this activity.	1	2	3	4	5
4. I didn't feel very sure of myself during this activity.	1	2	3	4	5
5. It wouldn't bother me to do more activities like this.	1	2	3	4	5
6. During this activity, I was so nervous that I forgot things.	1	2	3	4	5
7. I felt confident during this activity.	1	2	3	4	5
8. I felt self-conscious about speaking French during this activity.	1	2	3	4	5
9. I was nervous about performing in front of the researcher during this activity.	1	2	3	4	5

10. How nervous were you during this activity compared to when you complete activities in the French class?

1 - A lot less nervous
2 - Slightly less nervous
3 - The same
4 - Slightly more nervous
5 - Way more nervous

11. How useful do you think this activity was for you compared to activities you do in daily French class?

1 - A lot less useful
2 - Slightly less useful
3 - The same
4 - Slightly more useful
5 - Way more useful

Figure 5. Example of post-task anxiety questionnaire used in pilot study.

1. What is your UIN? ______

2. Did you have a preference regarding the activities (i.e, either the virtual reality (VR) or classroom activities? Why or why not?

______

3. Do you feel like one experience led you to be more successful over the other? Why or why not?

______

4. Did you feel more at ease/relaxed in either activity? If so, why do you think that is?

______

5. What are your first impressions regarding working with VR? What did you enjoy (if anything) and what would you like to change (if anything)?

______

6. Were you comfortable using the VR technology?

______

7. Did using VR impact how you feel about learning French? How so?

______

8. Did you find the VR environment to be immersive? Why or why not?

______

9. Did you ever forget that you were in a VR environment? If so, please elaborate.

______

10. Did you find yourself speaking more than usual during either the classroom or VR activities? If so, why do you think that is?

______

11. Did you notice any changes in your anxiety across the four activities? If so, what changes did you notice and why do you think they occurred?

______

12. Did any of the activities make you uncomfortable or self-conscious? If so, which ones and why?

______

13. Did the presence of your group members, your teacher, or the researcher impact how comfortable you felt during any of the exercises? If so, please elaborate.

______

14. Did being represented by an avatar impact how you felt during the VR activities? If so, how?

______

15. Please include any additional comments you may have.

______

Figure 6. Debriefing questionnaire used in pilot study.

Pilot Study Data Analysis

RQ1 about a possible relationship between learner's variables and the two types of anxiety was answered by analyzing participants' background information alongside initial self-reported foreign language anxiety scores and social interaction anxiety scores via a series of simple linear-regression models. To answer RQ2a and RQ2b, regarding the influence of the environment on self-reported and physiological anxiety, linear regression models were run on both the post-task self-reported anxiety data and participants' physiological measures. RQ2c about the relationship between participants' implicit and explicit anxiety measures was answered via Pearson's correlations. RQ3a, RQ3b, and RQ3c, which examined the impact of environment and/or anxiety on oral production, were addressed by means of the audio-recordings from all tasks which allowed participants' oral production to be rated for comprehensibility, intelligibility, and fluency. After all data was rated, a series of linear regression models served to determine the impact of the environment and anxiety on participants' oral production. Pearson's correlations were also conducted in order to examine the relationship between these three speech measures (RQ3d). Finally, examining participants' VR presence scores and their answers to the post-questionnaire allowed to explore how and why virtual reality impacted anxiety and how participants felt about using the technology for language learning (RQ4). Moreover, the Interaction Analysis Model (Hull & Saxon, 2009), was also employed to qualitatively analyze the conversations of an ANX+ focus group in order to see whether their speech patterns differed across the two environments.

Pilot Study Main Results

Regarding RQ1, female participants were found to have measurable higher foreign language anxiety and higher social anxiety. Time abroad was also found to lead to lower foreign language anxiety, albeit it did not impact social anxiety. Moreover, onset age of learning related to neither foreign language anxiety nor social anxiety. Finally, positive correlations were found between foreign language anxiety and social anxiety (r = .58, p < .001), foreign language anxiety and social phobia (r = .56, p < .001), and social anxiety and social phobia scores (r = .65, p < .001), indicating a clear relationship between these three constructs. Given this relationship, moving forward, participants will be grouped into anxiety profiles based on both their foreign language anxiety and social anxiety, as it can be expected that the way in which participants respond to different external and internal factors is influenced by both these constructs.

Concerning RQ2, participants self-reported lower anxiety in VR when compared to the classroom and also over time throughout the semester. The physiological data collected corroborated this finding. Indeed, participants' cortisol levels were lower in VR than in the traditional classroom, and ANX+ had higher cortisol levels than their ANX- peers. Moreover, ANX + participants experienced lower and less-varied heart rate when completing the VR sessions. Finally, it was found that participants' cortisol data weakly correlated with their self-reported data (r = .276, p = .14). However, no correlation was found between self-reported and heart rate data. Unfortunately, due to COVID-19 restrictions, salivary cortisol had to be removed from the current research study. Moreover, as no correlation was found between self-reported and heart rate data, it was decided that heart rate data in the current study would be used to track fluctuations in anxiety throughout the consensus-building tasks instead of as a second measurement of overall anxiety during a task.

RQ3 revealed that participants were more comprehensible and intelligible in VR compared to the classroom and that they also become more comprehensible and intelligible as the semester progressed. It was also found that ANX- participants were more comprehensible and intelligible than their ANX+ peers. However, a different pattern emerged for fluency. While ANX- participants were still found to be more fluent than those who were ANX+, participants were not necessarily more fluent in VR when compared to the classroom. Finally, positive correlations were found between participants' intelligibility and comprehensibility (r = .887; p <.001), intelligibility and fluency (r = .490; p <.001), and comprehensibility and fluency scores (r = .420; p <.001). Consequently, it was decided that all three of these constructs would be kept in the current study to further expand understanding of how participants' pronunciation and fluency are impacted by anxiety and environmental factors.

Regarding RQ4, participants' qualitative feedback indicated that they enjoyed and felt more comfortable in the VR environment, partially because they were shielded behind their avatars and were not able to be seen by their group members. This was especially true for ANX+ participants. Participants also found the VR environment to be quite immersive and fun to interact in. However, participants commonly noted the technological challenges that accompany using VR (e.g., controllers not working as they should, difficulty connecting to group members) and some felt that this led to them being less successful during VR activities. However, while participants' feedback on the qualitative questionnaire was enlightening, it was decided that semi-structured debriefing interviews would be used in the current study, with the aim of further delving into participants' perceptions of the learning environments.

Moreover, RQ4 found that an increased feeling of presence led to lower anxiety scores ($p = .048$), suggesting that participants' who felt more physically immersed in the VR environment were likely to experience lower anxiety. Therefore, to further explore the relationship between presence and anxiety, an Immersive Tendencies Questionnaire (ITQ) (Witmer & Singer, 1994), which evaluates the tendency for one to get immersed in various activities, was added to the current study. Finally, the qualitative analysis that was performed on an ANX+ focus group using the Interaction Analysis Model (Hull & Saxon, 2009) revealed that participants produced more and higher-level discourse in VR and when they self-reported lower anxiety. Therefore, this exploratory part of the pilot study was expanded in the current study in order to further understanding of how peer-to-peer interactions unfold in response to various internal and external factors.

Pilot Study Limitations

Several limitations were found when conducting the pilot study, notably (1) the rater instrument for comprehensibility and intelligibility and (2) the technological challenges of using VR.

Concerning the instrument that raters used to rate participants' comprehensibility and intelligibility, several problems were observed. While the instrument was found to be a reliable way to measure comprehensibility, choosing raters deliberately was found to be challenging. Indeed, it was found that one rater tended to rate the data harsher than the other two, most likely because he had been living in the U.S. for a shorter amount of time and was less accustomed to non-native speech. Therefore, moving forward it was decided to choose raters who have all been living and teaching in the U.S. for comparable amounts of time.

Moreover, intelligibility was found to be difficult to measure in the pilot study. Indeed, intelligibility has often been assessed in past research by having raters themselves do verbatim transcriptions of what they believe a speaker is saying. In an attempt to alleviate the substantial amount of time it takes to do this, the researcher transcribed all speech samples in the pilot study and simply asked raters to circle portions of the text where they found discrepancies in what they were hearing and reading. However, this method did not yield substantial interrater reliability. Therefore, it was decided moving forward to have raters do verbatim transcriptions of what they believe they hear a speaker to be saying.

Finally, in terms of technological challenges, the main issues that came about during this study were participants not fully understanding how to use the VR technology and navigate the *vTime XR* platform. In lieu of this, additional training of participants was added to the Spring 2020 data collection and kept for future semesters.

Moving from Pilot Study to Current Study

Following the pilot study, several changes were implemented before conducting the current study. These changes can be classified into two distinct categories: (1) changes made based on limitations and feedback from the pilot study and (2) changes that arose due to the COVID-19 pandemic. The changes made are shown in Table 1.

Categories	Instrument/Method	Modifications
Changes based on preliminary study	*Language Background Questionnaire*	Questions added: (1) to examine participants' past experience with and beliefs about technology in general and VR for language learning, (2) to include any other previously learned languages, (3) to account for participants being previously diagnosed with anxiety disorders, and (4) to elicit behaviors that participants use to cope with anxiety
	Consensus Building Activities	Two of the four consensus building activities were modified to better align with what is taught in the French course. Two additional consensus building activities were created since data collection in the current study took place over 6 sessions instead of 4.
	Post-task Anxiety Questionnaire	Questionnaire was changed from a 5-point Likert scale to a 4-point scale in order to match the baseline foreign language anxiety questionnaire that participants complete at the onset of the study.
	Debriefing Questionnaire	Questions added: to more specifically target how participants perceive using VR for language learning, to address the notion of embodiment in VR, and to target how the lack of or presence of visual cues impacts language learners' anxiety.
	Interviews	Follow-up debriefing interviews were added to further explore participants' perceptions of VR for language learning.
	Immersive Tendencies Questionnaire (ITQ)	As the degree of presence that participants felt was found to relate to anxiety, the ITQ was added to the set of questionnaires that participants complete at the beginning of the study to assess how prone they are to feeling immersed in virtual spaces.
	Anxiety Groups	As foreign language anxiety and social anxiety were found to be related, both FLA and SIAS/SPS scores will be used when breaking participants into different anxiety groups (as opposed to solely using FLA scores).
	Interaction Analysis Model	The Interaction Analysis Model will be applied to all 6 interactions of two focus groups to further explore whether and how peer-to-peer interactions vary across learning environments.
Changes made due to COVID-19	*Zoom*	Data was compared across three learning environments: a traditional classroom, Zoom, and VR
	VR Headsets	In order for the study to continue during COVID-19, VR headsets had to be purchased for each participant to use from home. Oculus Go headsets were purchased instead of Oculus Rift S headsets due to budget restrictions.
	Salivary Cortisol	It was no longer safe to collect saliva samples from participants. Salivary cortisol was therefore removed from the study.
	Heartrate	Heart rate data was collected on all participants. For the two focus groups, it was also triangulated with the Interaction Analysis Model findings to see how heart rate fluctuates in response to unfolding peer-to-peer interactions.

Table 1. Changes made from pilot study to current study

The Current Study

Purpose of the Current Study

The pilot study conducted from Fall 2019 to Spring 2020 revealed that students benefited from being immersed in a VR environment, in that it afforded them lower anxiety – both self-reported and physiologically – and more comprehensible and intelligible speech. This was particularly true for participants who experienced higher FLA in general. It also illuminated participants' initial perceptions of using VR for language learning. However, the current study expanded this work by further delving into participants' perceptions of *three* different learning environments: a traditional classroom, VR, and *Zoom*. As this study was conducted throughout the ever-changing COVID-19 health crisis, it also considered how participants' perceptions of these environments were actively shaped by the pandemic. Moreover, this study not only examined participants' speech at the individual level, but also as a collective unit by tracking how certain focus groups' peer-to-peer interactions unfolded and how heart rate fluctuated in response to them.

Research Questions

The current study addressed five research questions:

1) Was there a relationship at the onset of the study between participant background in terms of gender, time abroad, onset age of learning French, previous languages learned, and immersive tendencies and (a) general foreign language anxiety and (b) social anxiety? Was there a relationship between (a) and (b)?

2) To what extent did the learning environment (classroom, *Zoom*, or VR) impact participants' a) self-reported anxiety and b) heart rate during unrehearsed spontaneous interpersonal oral production?

3) To what extent does the learning environment and participants' anxiety impact their (a)

comprehensibility, (b) intelligibility, and (c) fluency? What was the relationship between (a), (b), and (c)?

4) How did focus groups' peer-to-peer interactions vary across learning environments? How did participants' heart rate fluctuate within a task in response to an unfolding interaction?

5) How did learners perceive the three learning environments?

Participants

38 (N = 38) intermediate learners of French as a foreign language participated in the current study. Data collection took place over three semesters: Fall 2020, Spring 2021, and Fall 2021. 9 (n = 9) participants were invited to take part in the study in Fall 2020, 17 (n = 17) in Spring 2021, and 24 (n = 24) in Fall 2021. All, except one participant in Fall 2021, consented to participate. However, as several students dropped the Oral French course in which this study was integrated during the first few weeks of the semester, 9 (n = 9) students actually participated in the study in Fall 2020, 13 (n = 13) in Spring 2021, and 18 (n = 18) in Fall 2021. Moreover, one student (n = 1) was removed from the group of Fall 2020 participants, leaving 8 (n = 8), because she did not complete any of the requirements of the study. Finally, as this study was integrated into an existing French course offered on campus, participants were occasionally absent from one or more sessions of data collection. Therefore, 5 (n = 5) participants attended all data collection sessions in Fall 2020, 9 (n = 9) in Spring 2021, and 5 (n = 5) in Fall 2021.

21 (n = 21) females and 17 (n = 17) males took part in this study. At the study's onset, participants had a mean age of 20.3 years (range: 18-32), and a mean onset age of L2 French learning of 13.14 years (range: birth-30). All participants except one (n = 1) belonged to Generation Z (i.e., born after 1995). 13 participants (n = 13) had been medically diagnosed with generalized anxiety disorder. 15 participants (n = 15) had only studied French as a foreign language whereas 24 (n = 24) had some experience with at least one other foreign language.

Finally, 12 (*n* = 12) participants had substantial immersive experience in a French-speaking environment, defined as prior experience studying abroad or living in a Francophone community or completing immersion schooling in French. Participants' demographic information is presented in Table 2. Only pseudonyms are used.

Semester	Group	Pseudonym	Gender	Age	Diagnosed Anxiety	Onset French	Additional Languages	Immersion
Fall 2020	1	Jessica	F	19	-	12	Chinese	Yes
Fall 2020	1	Nick	M	19	-	14	German	-
Fall 2020	1	Samantha	F	19	Yes	14	Spanish / Korean	-
Fall 2020	2	Melanie	F	20	Yes	14	German	-
Fall 2020	2	Iris	F	20	-	15	-	-
Fall 2020	3	Rick	M	25	-	14	-	-
Fall 2020	3	Amanda	F	19	-	0	Korean	Yes
Fall 2020	3	Rohan	M	20	-	12	Telugu	-
Spring 2021	4	Mark	M	21	Yes	11	-	-
Spring 2021	4	Talia	F	19	-	13	Yoruba	-
Spring 2021	4	Jacob	M	20	-	10	Chinese / Taiwanese	-
Spring 2021	5	Hashana	F	18	Yes	n/a	Urdu	-
Spring 2021	5	Eric	M	18	Yes	13	-	-
Spring 2021	5	Riley	F	18	Yes	12	-	-
Spring 2021	6	Mason	M	22	-	9	Russian / Spanish	Yes
Spring 2021	6	Hannah	F	19	Yes	15	-	-
Spring 2021	6	Mitchell	M	18	-	5	-	Yes
Spring 2021	6	Ella	F	19	-	13	-	-
Spring 2021	7	Nicole	F	18	-	14	-	-
Spring 2021	7	McKenzie	F	19	-	0	Spanish	Yes
Spring 2021	7	Katie	F	19	Yes	14	-	Yes
Fall 2021	8	Selina	F	26	-	12	Spanish / Catalan / Italian	Yes
Fall 2021	8	Lucia	F	20	-	16	-	-
Fall 2021	8	Levi	M	32	Yes	30	Portuguese / Spanish	-
Fall 2021	9	Martin	M	18	-	14	-	-
Fall 2021	9	Chris	M	22	-	5	Spanish	Yes
Fall 2021	10	Stacey	F	19	-	12	-	-
Fall 2021	10	Scarlett	F	26	Yes	20	Korean / Chinese / Japanese	-
Fall 2021	11	Isabella	F	20	Yes	14	Spanish	Yes
Fall 2021	11	Violet	F	19	Yes	12	Spanish	-
Fall 2021	11	Leo	M	18	Yes	12	-	Yes
Fall 2021	12	Hudson	M	20	-	17	Chinese	-
Fall 2021	12	Layla	F	20	-	12	Latvian / Dutch	Yes
Fall 2021	12	Brody	M	21	-	18	Chinese / Japanese / Taiwanese	-
Fall 2021	13	Valerie	F	18	-	12	Spanish	-
Fall 2021	13	Justin	M	19	-	14	Spanish	-
Fall 2021	13	Morgan	M	20	-	14	-	-
Fall 2021	13	Ethan	M	19	-	14	Spanish	-

Table 2. Participant information

During the current study, all participants were enrolled the same Oral French course that was used for the pilot study. Five different sections of this course (2 in Fall 2020, 1 in Spring 2021, and 2 in Fall 2021) participated in this study. In the first Fall 2020 section, 5 out of 5 students participated in this study (n = 5) and 3 out of 4 (n = 3) students from the second section participated. In Spring 2021, 13 out of 13 (n = 13) students participated. In the first Fall 2021 section, 6 out of 7 students participated in this study (n = 6) and 12 out of 12 (n = 12) students from the second section participated. Moreover, due to the ever-evolving COVID-19 health crisis, the format of the Oral French course varied across semesters. In Fall 2020, the course was offered in a hybrid format, with students having Wednesday class sessions face-to-face on campus and Monday and Friday sessions online on Zoom. However, in Spring 2021, the course was taught entirely online on *Zoom* and in Fall 2021 the course was taught entirely in person on campus.

Overview of Design

This study adopted a *convergent* mixed methods design which "involves collecting and analyzing two independent strands of qualitative and quantitative data in a single phase; merging the results of the two strands; and then looking for convergence, divergence, contradictions, or relationships between the two databases" (Creswell & Plano Clark, 2011, p. 116). Unlike in the pilot study which emphasized the quantitative data collected, the current study placed equal importance on both the qualitative and quantitative research methods, with the aim to develop a complete understanding of the phenomenon under study. Moreover, equally relying on both the quantitative and qualitative data allowed the researcher to more accurately account for all elements in learners' backgrounds and surrounding ecosystems which impacted their anxiety and learning experience. Figure 7 presents an overview of the methodology and design for the current study.

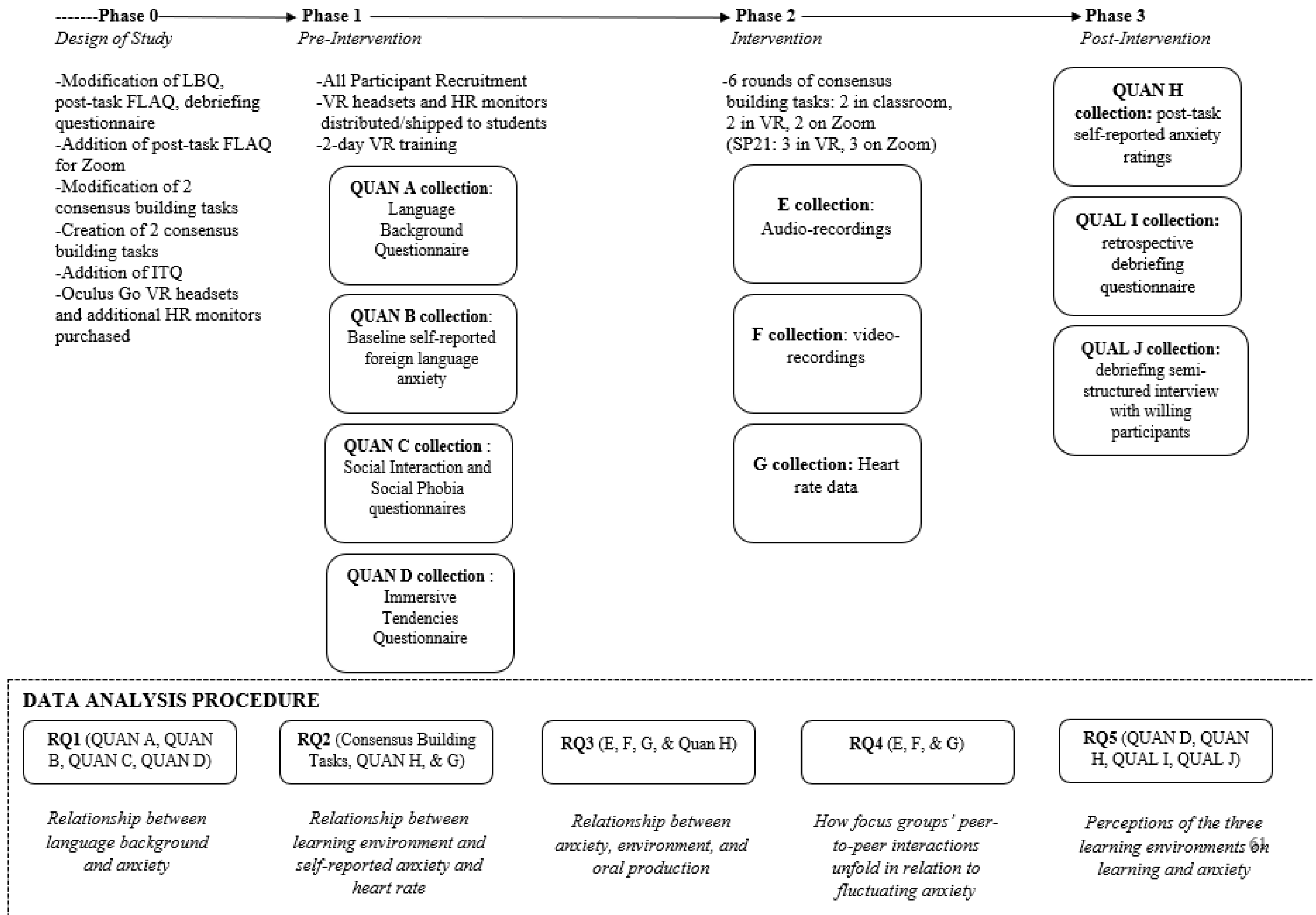
At the onset of the study, participants' language background, baseline self-reported FLA, social anxiety, social phobia, and immersive tendencies were established. Then, k-means clustering was used to classify participants into three groups using their baseline foreign language anxiety, social anxiety, and social phobia scores. K-means clustering is a type of statistical analysis that uses information provided to find homogenous subgroups within a larger dataset. The analysis reveals the optimal number of clusters, or groups, in a dataset and indicates which data (here, participants) fall within each cluster. Following the clustering analysis, three groups were ultimately formed: ANX+ (i.e., participants who had both high FLA and high social anxiety scores), ANX- (i.e., participants who had both low FLA and low social anxiety scores), and ANX± (i.e., participants who had high FLA *but* low social anxiety scores).

The intervention then consisted of six rounds of comparable three-way peer-to-peer interpersonal consensus building tasks (Appendix I) in French over a 12-week period in three different learning environments: two tasks in a traditional classroom-based environment (CR), two on *Zoom*, and two in a VR environment[1]. Participants' interactions were audio and video-recorded during each task. Moreover, heart rate was continuously collected during each task from all participants.

Following each task, participants self-assessed their anxiety via a shortened FLA questionnaire. At the end of the entire study, participants responded to an open-ended questionnaire targeting their perceptions of the three learning environments in relation to their

[1] It should be noted though that those participants who completed the study in Spring 2021 completed three tasks on Zoom and three in VR since the Oral French course was offered exclusively online, and no in-person data collection could be conducted.

learning and anxiety. All participants were also invited to take part in 15-to-20-minute semi-structured follow-up interviews in English with the researcher. The purpose of these interviews was to further explore participants' responses to the debriefing qualitative questionnaire and their perceptions of the three learning environments. 18 out of 38 participants agreed to be interviewed.



Key: LBQ = language background questionnaire; FLAQ = foreign language anxiety questionnaire; ITQ: immersive tendencies questionnaire; VR = virtual reality; HR = heart rate; QUAN = quantitative; QUAL = qualitative

Figure 7. Overview of current study design

RQ1 was answered by analyzing participants' background information alongside initial self-reported foreign language anxiety scores, social interaction anxiety scores, and immersive tendencies questionnaire scores. Merging of the post-task self-reported anxiety data and participants' physiological heart rate data allowed to answer RQ2 regarding the relationship between the learning environment and anxiety. RQ3, which examined the relationship between anxiety and oral production, was addressed by means of the audio-recordings from all tasks that allowed participants' oral production to be rated for comprehensibility, intelligibility, and fluency. Moreover, analyzing two focus groups' entire group conversations across all tasks via the Interaction Analysis Model (Hull & Saxon, 2009) allowed to answer RQ4, which explored how groups' peer-to-peer interactions varied across environments and according to anxiety. Merging the Interaction Analysis Model findings with participants' heart rate data also allowed to track how group interactions unfolded in response to fluctuations in anxiety. Finally, concerning RQ5, participants' open-ended questionnaire responses, interview data, and VR presence and immersive tendencies scores were triangulated to gain a complete understanding of participants' perceptions of the three different learning environments.

Data Collection

Table 3 presents an overview of data collection for this study.

Fall 2020			Spring 2021		Fall 2021		
Pre-Intervention Phase -- VR headsets and HR monitors distributed to participants							
Session	**Class 1** (*n* = 5)	**Class 2** (*n* = 3)	***Session***	**Class 3** (*n* = 13)	***Session***	**Class 4** (*n* = 6)	**Class 5** (*n* = 12)
Training 1 Week 1	VR Training 1 / LBQ, FLAQ, SIAS, SPS, & ITQ		**Training 1** Week 3	VR Training 1 / LBQ, FLAQ, SIAS, SPS, & ITQ	**Training 1** Week 1	VR Training 1 / LBQ, FLAQ, SIAS, SPS, & ITQ	
Training 2 Week 2	VR Training 2		**Training 2** Week 3	VR Training 2	**Training 2** Week 2	VR Training 2	
Intervention Phase -- 6 consensus building tasks in French							
CB #1 Week 3	**VR1** Post-FLAQ	**Zoom1** Post-FLAQ	**CB #1** Week 4	**VR1** Post-FLAQ	**CB #1** Week 3	**VR1** Post-FLAQ	**Zoom1** Post-FLAQ
CB #2 Week 5	**CR1** Post-FLAQ	**CR1** Post-FLAQ	**CB #2** Week 6	**Zoom1** Post-FLAQ	**CB #2** Week 5	**CR1** Post-FLAQ	**CR1** Post-FLAQ
CB #3 Week 7	**Zoom1** Post-FLAQ	**VR1** Post-FLAQ	**CB #3** Week 8	**VR2** Post-FLAQ	**CB #3** Week 7	**Zoom1** Post-FLAQ	**Zoom2**[2] Post-FLAQ
CB #4 Week 9	**VR2** Post-FLAQ	**Zoom2** Post-FLAQ	**CB #4** Week 10	**Zoom2** Post-FLAQ	**CB #4** Week 9	**VR2** Post-FLAQ	**VR1** Post-FLAQ
CB #5 Week 11	**CR2** Post-FLAQ	**CR2** Post-FLAQ	**CB #5** Week 12	**VR3** Post-FLAQ	**CB #5** Week 11	**CR2** Post-FLAQ	**CR2** Post-FLAQ
CB #6 Week 13	**Zoom2** Post-FLAQ	**VR2** Post-FLAQ	**CB #6** Week 14	**Zoom3** Post-FLAQ	**CB #6** Week 13	**Zoom2** Post-FLAQ	**VR2** Post-FLAQ
Post-Intervention Phase -- Debriefing questionnaire and semi-structured interviews conducted with willing participants							

Key: LBQ = language background questionnaire; FLAQ = foreign language anxiety questionnaire; SIAS: social interaction anxiety scale; SPS: social phobia scale; ITQ: immersive tendencies questionnaire; CB = consensus-building task; VR1: first VR task, Zoom1: first Zoom task, CR1: first classroom task.

Table 3. Data collection overview

[2] The Zoom2 and VR1 sessions for participants in Class #5 had to be switched suddenly at the moment of data collection. Indeed, their data collection was scheduled to take place in VR during class time at 11 a.m. on October 4, 2021. However, right before class began, Facebook witnessed a massive outage, and all platforms (including Oculus) went down.

Pre-Intervention Phase.

All data collection took place at the University of Illinois after receiving IRB approval (Appendix A). Written consent was received from all participants prior to the study (Appendix B). Then, all students were distributed a personal VR Oculus Go headset and Polar OH1 heart rate monitor to use throughout the semester for all study tasks. In Fall 2020 and Fall 2021, equipment was distributed during regular class time after receiving consent from participants. However, in Spring 2021, as the course was only offered online, the equipment was either shipped to or dropped off at participants' preferred address. Participants returned all equipment at the end of the semester.

At the onset of the study, participants completed a battery of questionnaires administered online via Qualtrics. Participants first completed a language background questionnaire (LBQ) (Appendix C) to elicit their background in terms of gender, age, any previous anxiety diagnosis, onset age of learning French, other languages learned, immersive experiences in a French-speaking country, technology habits/beliefs for language learning, and previous VR experience.

Participants' baseline self-reported anxiety was then established using two different questionnaires targeting anxiety as it relates to (1) foreign language learning and (2) to social interactions. To assess foreign language anxiety (FLA), participants completed a foreign language anxiety questionnaire (FLAQ) (Appendix D) that was adapted from Horwitz et al.'s (1986) Foreign Language Classroom Anxiety Questionnaire (FLCAS) and Woodrow's (2006) anxiety measurement instrument. Aspects of these two instruments were merged to create a 4-point Likert-scale new anxiety questionnaire that targeted oral production. These two instruments were chosen due to their reliability, as the FLCAS has been "widely employed" throughout research (Cao, 2011, p. 75), and Woodrow's (2006) instrument was found to be statistically “reliable and valid” (p. 323). Moreover, a 4-point Likert-scale was chosen instead of the original 5-point one in order to avoid neutrality and to encourage participants to report whether situations made them anxious or not.

In order to assess social anxiety, participants also completed the Social Interaction Anxiety Scale (SIAS) (Appendix E) and the Social Phobia Scale (SPS) (Appendix F) (Mattick & Clarke, 1998). While the SIAS has commonly been used to assess social interaction anxiety, the SPS has been used to assess performance anxiety (de Beurs et al., 2014). Both scales are composed of “20 self-assessment statements each to be rated on a five-point [Likert] scale” (de Beurs et al., 2014, p. 3). The SIAS and SPS were both chosen since they have been found to provide statistically consistent and reliable individual scores for performance and interaction anxiety (de Beurs et al., p. 1), and since this study’s intervention relied primarily on socially interactive tasks.

Lastly, a higher degree of *presence* in VR was found to lead to lower anxiety during the tasks in the pilot study. Therefore, in the current study, participants also completed an Immersive Tendencies Questionnaire (ITQ) (Appendix G), which examines participants’ “tendenc[ies] to experience more or less presence in artificial environments” (Witmer & Singer, 1994, p. 1). This questionnaire is composed of 26 self-assessments that are rated on a 7-point Likert-scale regarding how present or immersed participants feel when completing certain tasks (e.g., playing a video game) and one multiple choice question regarding what types of books participants typically read. The ITQ was chosen for this study, as it was created specifically to measure proneness to feeling present in artificial, virtual environments (Witmer & Singer, 1994), and since this study’s intervention focused on participants’ emotional responses to being immersed in virtual reality.

Then, participants underwent two 50-minute training sessions where they learned how to use the Oculus Go VR headsets, the social VR application *vTime XR*, and the Polar OH1 heartrate monitors. Part of this training involved teaching students to create their personal avatar, to add their classmates in *vTime XR*, and to connect with their group members in the application. After receiving this training, participants were paired with two other classmates and allowed to choose an immersive 360° environment within *vTime XR* in order to practice using the technology prior to the intervention phase of the study.

Intervention Phase.

The intervention phase of this study took place in three different learning environments: a traditional classroom, *Zoom*, and the VR platform *vTime XR*[3]. A description of each learning environment is presented below.

Classroom Environment.

Fall 2020 and Fall 2021 participants completed two consensus-building tasks in a traditional classroom environment on the University of Illinois at Urbana-Champaign's campus. Due to the ever-evolving COVID-19 health crisis, several precautions were in place to ensure participants' safety during both semesters. Specifically, students and the researcher followed all university and IRB COVID-19 safety measures, including: (1) mandatory twice-weekly COVID-19 testing or proof of COVID-19 vaccination, (2) participating in contact tracing, (3) mandatory quarantine and isolation if testing positive, (4) completing COVID-19 online safety training, (5) wearing face coverings (e.g., face mask (Fall 2021) or face shield (Fall 2020)), and (6) sitting six feet apart during class time (only during Fall 2020). Due to the nature of the current study, in Fall 2020, students were asked to please wear face shields (as opposed to face masks) so that they

[3]Spring 2021 participants only completed tasks on Zoom and in VR, as no in-person data collection could be conducted.

could communicate more easily with their group members. However, per university policy, all students were required to wear face masks during Fall 2021. All this information was detailed to students in the course syllabus (Appendix H). Examples of students completing consensus-building tasks in the classroom are shown in Figures 8 and 9. All participants consented to having their pictures shared.

Figure 8. Fall 2021 students completing a consensus-building task in the classroom.

Figure 9. Fall 2020 students completing a consensus-building task in the classroom.

Zoom Environment.

Fall 2020 and Fall 2021 participants completed two consensus-building tasks on *Zoom*, and Spring 2021 participants completed three. *Zoom* is a secure, online video-conferencing platform that allows users to connect with each other in private meeting spaces. During the *Zoom* activities, participants worked with their group members in break out rooms for the duration of the consensus-building task. To best mirror the classroom environment, students were instructed to leave their cameras on during the activity. Examples of students completing consensus-building tasks on *Zoom* are shown in Figure 10. All participants consented to having their picture shared from *Zoom*.

Figure 10. Spring 2021 students completing a consensus-building task on Zoom.

Virtual Reality Environment.

Fall 2020 and Fall 2021 participants completed two consensus-building tasks in the VR environment, and Spring 2021 participants completed three. All VR tasks were completed in the social VR application, *vTime XR*. *vTime XR* was created primarily for conversing in VR and offers twenty-two different locations in which users can immerse themselves with up to 3 friends (i.e., 4 total users at a time). This strong focus on communication is the reason for which *vTime XR* was chosen for this study. It was important to have an environment in which participants would primarily be conversing with their peers and not necessarily focusing on doing a specific task related to the VR itself, as it has been found that "activities in which the VW [VR] plays a central role generate less oral interaction" and oral interaction was the key focus of this study (Melchor-Couto, 2016, p. 107).

vTime XR's twenty-two locations range from traditional settings (e.g., a meeting boardroom, a Paris rooftop bar) to more extravagant contexts (e.g., a space shuttle, an abandoned underwater ship). To increase presence, all locations offer fully immersive 360º environments that include visual and audio effects. For example, users interacting at the Paris rooftop bar can hear background noises such as the sound of cars driving by on the street below or other patrons dining and can see smoke coming from the chimney tops of surrounding buildings. Depending on their personal preference, users can also adjust the volume of the surrounding sound effects to make them louder or softer.

For the consensus-building tasks in this study, three different locations were used: *Terrasse de l'amour* (e.g., the Paris rooftop bar), *The Retreat* (e.g., a Japanese outdoor garden), and *The Boardroom* (e.g., a meeting room in a skyscraper). These locations were chosen because they related well to the themes of the consensus-building tasks and offered a realistic context in which students could complete the tasks. For example, *The Retreat,* was chosen for a consensus-building task on sustainability and the environment since it immersed participants in a convincing, naturalesque setting. Examples of students completing consensus-building tasks in these three environments are shown in Figures 11 through 16.

Figure 11. Fall 2020 students completing a consensus-building task at *Terrasse de l'amour*.

Figure 12. Spring 2021 students completing a consensus-building task at *Terrasse de l'amour*.

Figure 13. Fall 2020 students completing a consensus-building task at *The Retreat*.

Figure 14. Spring 2021 students completing a consensus-building task at *The Retreat*.

Figure 15. Fall 2020 students completing a consensus-building task in *The Boardroom*.

Figure 16. Spring 2021 students completing a consensus-building task in *The Boardroom*.

Consensus-Building Tasks.

The intervention phase relied on 6 comparable three-way peer-to-peer interpersonal consensus-building tasks in French created by the researcher, and inspired by Mroz (2012), to accompany themes being covered in the Oral French course at the time of data collection. These themes included: (1) YouTube content creators, (2) technology, (3) sustainability/environmental issues, (4) education, (5) social media, and (6) sports or art and culture (Appendix I).

Consensus-building activities were chosen, as they "include collaborative elements [that] have been reported as being effective […] in that they involve 'creative and active language use' […] and [since they] motivate active participation because there is no single correct answer and […] learners are encouraged to take on active roles" (Deutschmann et al., 2009). Moreover, having to negotiate a situation in French and to reach a consensus, (i.e., an Advanced proficiency skill (ACTFL, 2012)), was useful to probe these participants and elicit anxiety. By presenting a linguistically challenging situation in both the classroom, *Zoom*, and VR tasks, it was possible to compare anxiety across the three environments.

Before completing any consensus building tasks, participants were randomly assigned to a group of 3 students. Groups of 3 were chosen in order to keep groups small enough that students would be encouraged to actively participate, but large enough to promote vibrant discussion. Moreover, students worked with their same group throughout the semester when possible. However, since students occasionally dropped the course or were absent from class, students sometimes worked in groups of 2 or 4 or with different students.

Upon being placed in their groups, students then received the task instructions and read through them as a class in French. The researcher clarified any questions students had regarding vocabulary or the task itself in French. Each task consisted of specific instructions regarding what students needed to precisely discuss and reach a consensus on. For each task, students were also assigned to play specific hierarchical, opposing roles in the conversation in order to see if this added dynamic influenced their anxiety or social interactions. Table 4 gives an overview of each task theme, and the roles students were assigned.

Consensus Building Task	***Theme***	***Main Objective***	***Role 1***	***Role 2***	***Role 3***
1	YouTube Content Creators	Come up with an idea for a new YouTube series for the social media company, *Roxane*, that you work for in Paris.	A new employee that was recently hired.	The boss of *Roxane*.	An established worker of *Roxane*.
2	Science & Technology	Come up with an idea for a new technology that could solve a problem in society.	PhD student in engineering at the *Université de Sorbonne*	The CEO of the biggest technology developer in Paris.	Professor of engineering at the *Université de Sorbonne*.
3	Environment	Organize a workshop that will teach locals how to protect the environment.	Director of the *Champaign County Sustainability Network*	Student majoring in Ecology and Environmental Sciences.	Volunteer who is interested in the environment.
4	Education	Decide how budget cuts in the school will be handled.	Principal of the school.	Teacher.	Student representative.
5	Social Media	Come up with an idea for a new type of social network.	Mark Zuckerberg.	An established worker at *Facebook*.	Intern at *Facebook*.
6[4]	**FA20&21**: Sports	Work as part of the planning committee for the 2024 Paris Olympic games.	President of the planning committee.	Vice-President of the planning committee.	Treasurer of the planning committee.
	SP21: Art/Culture	Work as part of the planning committee for the 2021 *Festival de Cannes.*	President of the planning committee.	Vice-President of the planning committee.	Treasurer of the planning committee.

Table 4. Overview of consensus-building tasks

For example, for the theme of "education," students had to reach a consensus regarding budget cuts in a school system that was in financial crisis (Figure 17). Students were assigned to play either the school principal, a teacher, or the student representative. All students received

[4]Spring 2021 participants began the study tasks 2 weeks later than those who partook in Fall 2020 and Fall 2021 to allow time for shipping all equipment to participants. Consequently, their sixth consensus building task was slightly modified to better align with the topic being covered in class at the time. However, the structure of the task was kept as similar as possible.

details regarding how their character thought it would be best to handle the budget cuts. Students then had to use this information to make an argument as to why the budget cuts should be handled in that specific way. They had 20 minutes to convince each other of their views and to come to an agreement that suited all of them. Following all consensus building tasks, a brief 10-minute class discussion took place where students shared and explained with the class the consensus that they had come to.

Thème 4 : Education

Introduction :

Le système scolaire a beaucoup de problèmes en ce moment. Malheureusement, votre lycée est en crise financière et, du coup il y a des coupes budgétaires. Dans un effort pour trouver une solution, une réunion va avoir lieu avec le directeur du lycée, l'un des enseignants principaux et le représentant des étudiants. Votre tâche : discutez avec les membres de votre groupe pour décider où vous pouvez réduire vos dépenses. Après avoir discuté, présentez votre solution à la classe.

Utiliser votre rôle pour guider votre discussion :

Rôle 1 : Le directeur de l'école
Vous avez quelques idées sur la manière de réduire vos dépenses.

1. Eliminer la technologie qui est dans les salles de classe ?
2. Augmenter le nombre d'étudiants dans chaque classe ?
3. Réduire les activités extrascolaires ?
4. Réduire le nombre de bourses que le lycée offre aux étudiants.

Cependant, vous ne savez pas quoi faire. Vous voudriez discuter avec l'un des professeurs de l'école et le représentant d'étudiant pour avoir leurs opinions.

Rôle 2 : L'un des enseignants du lycée
Pour vous, augmenter le nombre d'étudiants dans chaque classe n'est pas du tout possible. Il y a déjà trop d'étudiants par classe et il est trop difficile d'enseigner. En plus, faire cela réduit la qualité de l'enseignement pour les étudiants parce qu'il est plus difficile de leur donner des réactions individuelles. En plus, vous préférez ne pas réduire le nombre de bourses que le lycée offre aux étudiants parce que cela permet aux étudiants qui n'ont pas beaucoup d'argent de venir au lycée.

Pour vous, la meilleure option, c'est d'éliminer la technologie qui est dans les salles de classes. Sans formation, la technologie qui coûte souvent chère est très difficile à utiliser pour les enseignants et elle peut être distrayante pour les étudiants.

Rôle 3 : Le représentant d'étudiant
Pour vous, éliminer la technologie qui est dans les salles de classe n'est pas une bonne idée. Les étudiants sont jeunes et ils sont habitués à utiliser la technologie. En plus, des études montrent que les étudiants, surtout ceux qui font partie de la Génération Z, apprennent mieux en utilisant la technologie parce qu'ils sont plus intéressés.
En plus, vous préférez ne pas réduire les activités extrascolaires parce que vous pensez qu'elles sont bonnes pour la santé mentale des étudiants. Pour vous, la meilleure option, c'est augmenter le nombre d'étudiants dans chaque classe. Si les enseignants utilisent plus de technologie, ils pourront enseigner à plus d'étudiants en même temps.

Figure 17. Education consensus building task

Participants alternated between completing tasks in the classroom, on Zoom, and in VR over a twelve-week period, with two weeks between each session. Each section of the course began either in *Zoom* or VR in order to prevent any task order effects.

All six tasks were audio and video-recorded so that group interactions could be compared across environments. Moreover, to capture heart rate data, participants wore Polar OH1 heart rate monitors around their forearms for the duration of the twenty-minute task.

Post-Intervention Phase.

Immediately following each task, participants completed a shortened version of the original FLAQ online via Qualtrics to assess their self-reported anxiety levels during the activities (Appendices J, K, and L). All post-task questionnaires were administered in English. The questionnaire following the VR activities was also adapted using Roy (2014) to specifically include 8 questions targeting presence. Presence, or "the sense of 'being there' within a virtual environment' (Petersen, 2011, p. 70), has been found to impact performance and to be higher in participants who experience stronger immersion (Roy, 2014). Moreover, as students' roles for consensus-building tasks were hierarchical and this could have triggered anxiety, two open-ended questions targeting this dynamic were included: 1) *Did the role that you played in the conversation influence how you interacted with your peers? How so?* and 2) *Did the role that you played in the conversation impact your anxiety? How so?* Finally, a final question was included that asked students to report how often, for how long, and for what purpose (if any) they had used their VR headset in the two weeks prior.

At the very end of the study, participants spent on average 15 minutes responding in English to an open-ended questionnaire, targeting how they perceived the three learning environments and how they felt they impacted their experience (Appendix M). Questions 5, 13, 14, 15, and 16 were designed to target how and why participants' anxiety varied across environments, while questions 2-4 aimed to elicit whether participants felt they were more successful speaking French in any of the tasks. Finally, questions 6-9 targeted participants' perceptions of the VR technology and how easy they found it to use, while questions 10, 11, 12, and 17 specifically aimed to capture how immersed participants found the VR environments. Participants were encouraged to write several sentences as an answer to each question in order to elicit elaborate responses.

Lastly, all participants were asked to take part in voluntary 15-to-20-minute follow-up semi-structured interviews in English on *Zoom* to further discuss their experiences. 18 out of 38 participants agreed to participate and received a $5 Amazon gift card as compensation. All interviews were audio-recorded.

The aim of these interviews was two-fold: 1) to give participants a chance to elaborate upon their original questionnaire responses and 2) to give the researcher the opportunity to ask follow-up questions when participants' responses were unclear. Therefore, the researcher used participants' debriefing questionnaire responses to guide the interview and asked participants questions such as: "Can you tell me more?" "Could you elaborate here" and "Could you clarify what you meant when you mentioned X"? Moreover, to further pinpoint moments of anxiety that participants experienced throughout the tasks, the researcher asked all participants to try to recall specific moments when they remembered feeling particularly anxious (and conversely, particularly relaxed) during the study and detail what was happening during those times.

Data Analysis

All data analyses were conducted using *R* (Appendix N).

Research Question 1 (RQ1).

RQ1 examined the relationship between participant background and foreign language anxiety and social anxiety. First, participants' FLAQ, SIAS, SPS, and ITQ questionnaires were scored following appropriate protocol for each test. Possible scores ranged from 27-108 for the

FLAQ and 0-80 for the SIAS and SPS, with higher scores indicating higher foreign language anxiety and/or social anxiety. For the ITQ, possible scores ranged from 26-182, with a higher score indicating a higher tendency to become immersed. A series of simple linear-regression models were then run in *R* to examine how various participant background information (gender, onset age of learning, time abroad, previous anxiety diagnoses, previous languages learned, immersive tendencies, etc.) predicted self-reported anxiety at the onset of the study.

Then, k-means clustering analysis was used to classify participants into groups according to their baseline FLA, social anxiety, and social phobia. K-means clustering is a type of analysis that uses data provided (e.g., FLAQ, SIAS, and SPS scores) to create homogenous subgroups within the dataset. It is therefore an ideal way to systematically classify participants into various types of learner profiles based on their background information. In this instance, the *factoextra* package in *R* was first used to establish the optimal number of clusters in the dataset using participants' FLAQ, SIAS, and SPS scores. The optimal number of clusters was determined to be 3. Then, using the base *R* function *kmeans()*, k-means clustering analysis was performed on the data and the three different clusters were defined. The clusters and their "centers" (i.e., the mean score on each test for participants in each cluster) are displayed in Table 5.

Cluster	**FLAQ**	**SIAS**	**SPS**
1	50.68	15.70	7.70
2	74.27	50.64	41.00
3	78.81	18.38	19.75

Key: FLAQ = foreign language anxiety questionnaire score; SIAS = social interaction anxiety scale score; SPS = social phobia scale score

Table 5. K-means clusters used to create anxiety groups.

Upon inspecting the characteristics of each cluster, three participant groups were created. Cluster 1 was labeled as ANX- (i.e., participants who had both low FLA and low social anxiety scores), Cluster 2 as ANX+ (i.e., participants who had both high FLA and high social anxiety scores), and Cluster 3 as ANX± (i.e., participants who had high FLA *but* low social anxiety scores). 11 participants were classified as ANX+, 20 as ANX-, and 8 as ANX±.

Research Question 2a and 2b (RQ2a & b).

RQ2 served to investigate the impact of the learning environment on (a) participants' self-reported anxiety and (b) physiological anxiety (i.e., heart rate).

Concerning RQ2a, participants' post-task FLA questionnaires were first scored to determine an anxiety score for each task based on point values for each rating. Possible self-reported anxiety scores ranged from 11-44, with higher scores indicating higher anxiety. Using the *lme4* and *lmerTest* packages in *R*, a linear regression model with post-task self-reported anxiety score as a dependent variable, environment as an independent variable, anxiety group as a fixed factor (i.e., ANX+, ANX–, and ANX±), and participant as a random factor was conducted to determine if the learning environment (i.e., the classroom, *Zoom*, or VR) had a significant impact ($p < .05$) on self-reported anxiety. Anxiety group was included as a fixed factor instead of participants' numeric baseline anxiety score, as this measure of anxiety is less susceptible to being influenced by outliers.

Moreover, in an effort to respond to Plonsky's (2015) call to include more descriptive statistics and effect sizes in SLA research, pairwise comparisons, effect sizes, and confidence intervals were calculated for all analyses in the study using the *dplyr*, *emmeans* and *EMAtools* packages in *R*. For any comparisons across tasks (i.e., CR1, CR2, Zoom1, Zoom2, VR1, and VR2), effect sizes were interpreted according to Plonsky and Oswald's (2014) recommendation for SLA studies that contain within-group contrasts (i.e., .60 = generally small effect, 1.00 = medium effect, and 1.40 = large effect). For effect sizes of participant group (i.e., ANX+, ANX–, and ANX±), results were interpreted following Plonsky and Oswald's (2014) recommendation for between-group comparisons (i.e., .40 = generally small, .70 = medium, 1.00 = large).

Regarding RQ2b, participants' HR data was extracted from the Polar OH1 HR monitors. Using *R*, the data was then examined using *ggplot2* and descriptive statistics in order to determine if the learning environment impacted the HR of participants. Minimum beats per minute (bpm), maximum bpm, mean HR, median HR, and SD were calculated for each session for all participants.

Research Question 3 (RQ3).

RQ3 explored the impact of learning environment and anxiety on participants' oral comprehensibility, intelligibility, and fluency.

First, the researcher prepared participants' audio-recorded data to be rated by using *Audacity* to select twenty-second speech samples from three key points during each task. This yielded 18 speech samples total per participant (573 total: 132 in Fall 2020, 201 in Spring 2021, and 240 in Fall 2021. For all tasks, speech samples were selected from when participants were either (a) providing an argument to support their opinion, (b) constructing hypotheses, and (c) narrating in various time frames. These three communicative functions were chosen, as they have been identified as characteristics of Advanced proficiency (ACTFL, 2012).

Then, three native-speaker raters were chosen to evaluate all speech samples for comprehensibility and intelligibility. At the time of rating, all raters had been teaching French in the U.S. for at least 8 years, and therefore had extensive experience with second language French learners. This was important, as the pilot study revealed low interrater reliability between raters who had not been in the U.S. for comparable amounts of time.

In the initial pilot study, raters evaluated intelligibility by (1) first listening to a twenty-second speech sample, (2) then reading the transcription for the sample, and (3) finally circling any parts of the transcription that did not align with what they heard. Although intelligibility is often assessed by having raters transcribe what they are hearing, this method was chosen in order to alleviate the substantial time commitment this requires. However, substantial inter-rater reliability was not found in the pilot study. Therefore, in the current study, it was decided that raters would actually transcribe the samples themselves following a protocol that the researcher created one-on-one with one of the raters (Figures 18 & 19). Creating the initial protocol took three hours. The purpose of this was to anticipate questions that would arise when transcribing the data and pre-determine how such situations should be handled so that all raters would transcribe the data systematically.

Next, all raters completed a 2.5-hour group training session to learn how to use the rating protocol for both intelligibility and comprehensibility. This training session was made up of two parts: 1) explaining the intelligibility protocol to raters and then having them complete 54 practice intelligibility transcriptions and 2) explaining the comprehensibility protocol and then having raters complete 54 practice comprehensibility ratings. Speech samples from the pilot study were used for all practice ratings. This training served to provide raters the opportunity to clarify the rating protocols and to ensure rater calibration. After the training, all raters independently evaluated every speech sample (N = 573) and interrater reliability was calculated. To establish intra-rater reliability, the main researcher also assigned each rater a random selection of 10% of the speech samples to re-rate.

Intelligibility Transcription Protocol

Please strictly adhere to the following protocol to transcribe this dataset.

1. First, **write the name** of the audio sample before each transcription.
2. Then, listen to the 20-second speech sample. Please listen to the sample attentively, but **only one time**. Please **listen to the entire speech sample before transcribing anything**.
3. **Immediately after**, transcribe what you heard the speaker say. Do not spend more than 1-minute transcribing the speech.

You should transcribe what you **understand** the speaker to be saying (i.e., if you hear "je vais au parc hier" but understand that the speaker means "je suis allé(e) au parc hier," you should transcribe the latter). You will therefore find yourself correcting grammatical and pronunciation errors.

You do not need to transcribe "ums" and pauses.

If a speaker uses an English word or invents a word, please just transcribe what you hear. You do not need to translate the word for them or use the real French word[1].

At times, you will hear more than one speaker in the recording. Please transcribe the one that speaks the majority of the time (this is usually the speaker that speaks first).

If you cannot remember all of what a speaker said, please transcribe "[forgot]" at the point in the transcription where you think you are forgetting something. If you can remember any details (i.e., the number of words you are forgetting, the part of speech, etc.), please include those as such "[forgot: 1 word, verb]"[2]

If you cannot understand at all what a speaker said because of the errors, please transcribe "[unintelligible]" at the point in the transcription where it occurs. If you think you can understand any details (i.e., the number of words you are hearing, the part of speech, etc.), please include those as such "[unintelligible: 2 words]"[3]

If you cannot understand at all what a speaker said because of sound quality (background noise, speakers talking over one other, Zoom cutout), please transcribe "[inaudible]" at the point in the transcription where it occurs. If you think you can understand any details (i.e., the number of words you are hearing, the part of speech, etc.), please include those as such "[inaudible: 1 word]"[4]

At times, you might hear a speaker reference the name of a TA or fellow student. Please transcribe "[name]" at this point in the recording[5]

If you cannot remember the exact word order of part of the utterance, please underline the part of the utterance where you are unsure and put in brackets "[WO]" at the end of the utterance.[6]

Figure 18. Intelligibility transcription protocol

Examples of speakers using *English or non-existent words*[1]:

Speech Sample 31-09:

Transcription: C'est une série Youtube donc on peut utiliser le *clickbait*. Je ne sais pas s'il y a un bon titre pour une série mais…

Speech Sample 30-07:

Transcription: Nous pouvons faire une *demme* du voyage alors les pays différents uhmmm

Examples of when part of utterance is *forgotten*[2]:

Speech Sample 29-08:

Transcription: que le titre est un peu *misleading* mais je sais que nous avons discuté que pour chaque endroit le public [forgot : 1 word, verb] chaque destination

Example of when part of utterance is *unintelligible*[3]:

Speech Sample 02_02:

Transcription: Nous ne nous savons pas qui nous écoute, par exemple le gouvernement, peut-être, [unintelligible] ce sont des *spies*

Example of when part of utterance is *inaudible*[4]:

Speech Sample 02_03:

Transcription: Nous sommes à l'étape 2 où nous devons trouver un problème et nous avons inventé un robot qui travaille dans les fermes [inaudible]

Example of when a *name* is used[5]:

Speech Sample 29_09:

Transcription: Je suis d'accord avec [name] parce qu'il y a beaucoup de régions en France donc si nous visitions pas seulement Paris, il y a des gens qui…

Example of when *word order* is forgotten[6]:

Speech Sample #: 32-02

Transcription: je pense qu'il peut… qu'il peut… que nous pouvons utiliser l'intelligence artificielle pour les choses les plus dangereuses, pour les humains [WO]

Figure 19. Intelligibility transcription protocol examples

Following other researchers (Huensch & Nagle, 2021; Nagle & Huensch, 2020; Munro & Derwing, 1995a), raters were asked to transcribe what they understood in each 20-second sample to evaluate intelligibility. As intelligibility refers to "the extent to which a speaker's [intended] message is actually understood" (Munro & Derwing, 1995a, 1995b, as cited in Thomson, 2018,

p. 4), raters were specifically asked to transcribe what they understood the speaker to be trying to say, even if that entailed correcting grammatical and pronunciation errors. Specifically, raters were first asked to listen only one time to the entire 20-second speech sample without transcribing anything. Then, immediately after, they were told to transcribe what they understood.

All raters' transcriptions were then compared to transcriptions of the data that were done conjointly by the researcher and the native French speaker who had instructed the course. Then, token sort ratio (TSR), a specific method of fuzzy string matching, was used to compare raters' transcriptions to the target sentences. TSR is "a consistent, highly efficient, and accurate metric for automated assessment of listener transcripts" and has shown "high correlations with human-generated scores (best correlation: $r = 0.940$) and a strong relationship to acoustic markers of speech intelligibility" (Bosker, 2021, p. 1). Using an online tool for TSR that was developed by Bosker (2021), the percentage of words transcribed or understood correctly by raters in each twenty-second utterance was then calculated for each rater. Then, using the *psych* package in *R*, ICC3 was found to be .81, F (5.4, 569) = .81, $p < .001$, indicating strong reliability: 95% CI [.79, .83]. Raters' scores were thus averaged to establish an intelligibility score for each participant in each environment.

After having transcribed all 573 speech samples for intelligibility, raters used a reversed-version of Munro and Derwing's (1995a) 9-point comprehensibility scale (1 = "hard to understand" & 9 = "easy to understand") to assess comprehensibility and indicate how easy or difficult they found understanding the speaker to be (Figure 20). Following other researchers (Isaacs & Thomson, 2013; Trofimovich & Isaacs, 2012), the scale was reversed in order to render the results more reader-friendly and intuitive. Munro and Derwing's (1995a) scale was chosen, as this scale has been widely employed in comprehensibility research and has proven to be reliable.

Speech Sample #:

The speaker to whom I just listened…

was **hard** to understand 1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 was **easy** to understand.

Figure 20. Comprehensibility rating protocol

Using the *psych* package in *R*, ICC3 was found to be .84, *F* (6.2, 569) = .84, $p < .001$, indicating strong reliability: 95% CI [.82, .86]. Raters' scores were thus combined to establish an average comprehensibility score for each participant in each task.

For fluency, the total number of full words produced during each twenty-second sample were counted and averaged to establish an overall fluency score for each participant during each task.

Finally, simple linear regressions were then conducted to identify any influence of environment and/or self-reported anxiety on comprehensibility, intelligibility, or fluency. Subsequent pairwise comparisons were conducted and effect sizes (i.e., Cohen's *d*) and confidence intervals were also used in addition to *p*-values for more fine-grained results. Furthermore, a series of Pearson's correlations was conducted to determine the relationship between comprehensibility, intelligibility, and fluency.

Research Question 4 (RQ4).

RQ4 explored how the peer-to-peer interactions of two focus groups of three students each ($n = 6$) unfolded across the three environments during the consensus-building tasks in response to their anxiety.

First, two focus groups were selected from the Fall 2020 participants. Focus Group 1 (FG1) was comprised of Samantha (ANX+), Jessica (ANX+) and Nick (ANX-) and Focus Group 2 (FG2) of Rick (ANX-), Rohan (ANX-), and Amanda (ANX+) (all represented by their pseudonyms). These two groups were chosen for three reasons: (1) they completed tasks in all three learning environments (i.e., the classroom, *Zoom*, and VR), (2) all group members attended most of the activities, and (3) one group was primarily composed of ANX+ and the other of ANX- students. This was important, as it allowed to compare interactions within a primarily ANX+ group to those of a primarily ANX- group.

Then, using the video recordings of each groups' consensus-building tasks, the researcher transcribed verbatim each groups' discussions using a free annotation software designed specifically for linguistics research called *ELAN*. *ELAN* allows annotators to create "tiers" for each participant where they can then transcribe the participants' speech alongside the video. Figure 21. shows a picture of the *ELAN* interface and a portion of the transcription of one of FG1's classroom consensus-building tasks.

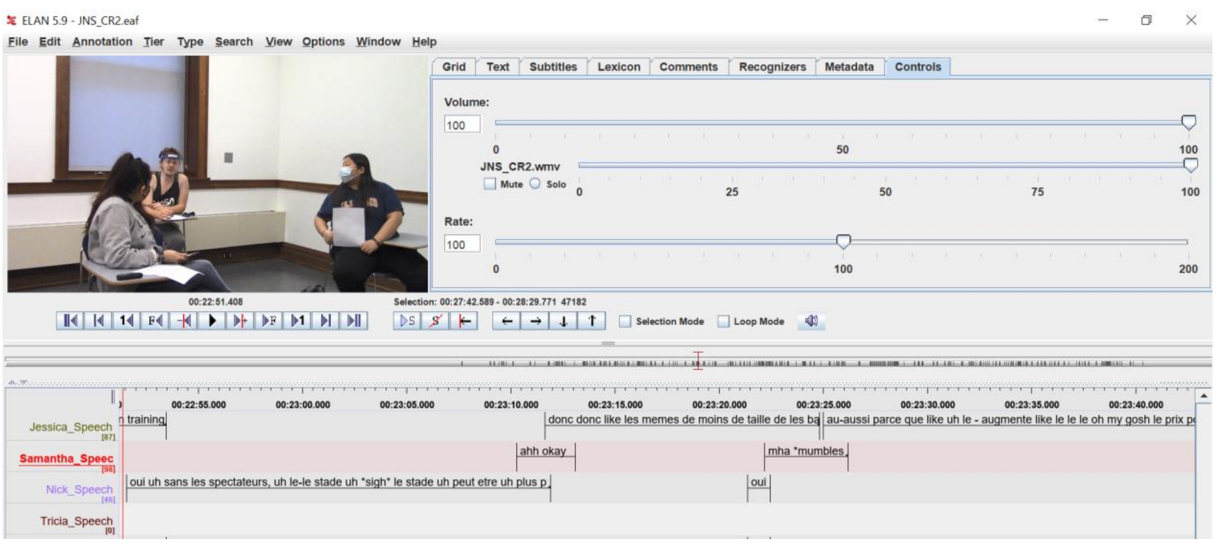


Figure 21. *ELAN* annotation interface

Next, two separate coders independently coded the two FGs' conversations into seven incremental levels of interpersonal discourse, ranging from simple to more complex instances of negotiation of meaning, using the Interaction Analysis Model (IAM) (Hull & Saxon, 2009) (Figure 22). The purpose of using this model was to explore whether participants' discourse patterns seemed to differ based on either the environment or their self-reported anxiety level for the specific task they were completing.

	Code	Definitions	Indicators
1	Direct instruction(s) to the group	Initiating new activity for the group	1a. statements that cause the group to undertake a discussion of on a totally new subject
			1b. statements that provide clarity to a previous instruction
2	Sharing new information	Information is provided that has not been previously discussed	2a. a statement of observation or opinion
			2b. a simple response to a question or instruction
			2c. definition, description, or identification of a problem
3	Situated definition	Information is validated through a socially-shared, distributed consciousness	3a. statements of agreement
			3b. realization of agreement
			3c. providing corroborating example(s)
			3d. providing encourage for a previously expressed idea
			3e. basic questions of clarification
4	Intersubjective/dissonance	Inconsistency is discovered between a new observation and the learner's existing framework of knowledge	4a. identifying or stating areas of disagreement
			4b. asking and answering questions
			4c. restating some else's position
			4d. clarifying one's own position (without substantial changes to that position)
5	Negotiation/co-construction (semiotic mediation)	Higher mental functioning that attempts to bridge differences in situated definitions	5a. clarifying someone else's position
			5b. re-proposing an idea previously provided to the group
			5c. statement that appears new but that may contain elements from others
6	Testing tentative constructions	Testing new ideas developed through the group	6a. "what if" questions/statement
			6b. proposed behaviors that incorporate newly constructed ideas
7	Reporting application of newly constructed knowledge	Behavior is provoked by discussions resulting in reports about activities in which a participant engaged	7a. statements indicating that new ideas are being tried
			7b. reports of attempts (successful or unsuccessful) to implement a new concept or idea

Figure 22. Interaction Analysis Model (Mroz, 2015).

Both coders used *ELAN* to classify participants' utterances into one of the seven categories. This allowed the coders to have access to the video recordings that accompanied the transcriptions and to have the contextual support needed to understand the FGs' interactions and accurately code the IAM.

Both coders would code an entire video before meeting to discuss the codes they had chosen. Upon meeting, initial agreement was found to be 81.2%. Any disagreements in coding were discussed by the coders until agreement was reached. Solutions included either choosing a code that one of the coders had already provided or choosing a completely new code for the data. All solutions to disagreements were documented in memo-trails throughout the meeting to ensure systematic coding moving forward. Figure 23 shows an excerpt of the coded data in *ELAN*.

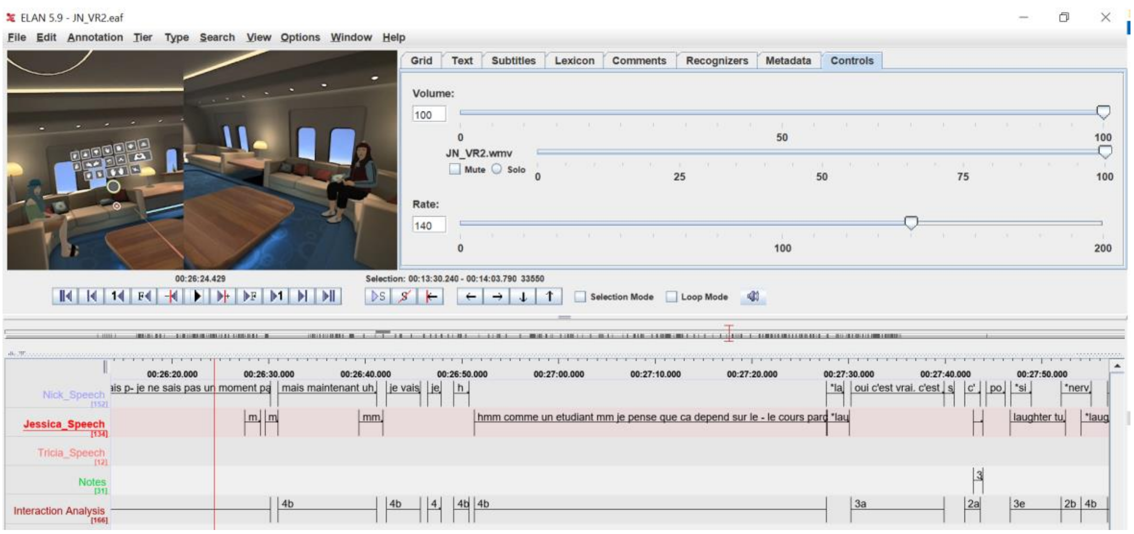


Figure 23. Excerpt of coded data using the IAM

Through coding, participants' utterances were transformed into a number that corresponded to incremental levels ranging from 1 to 7 which allowed for quantitative statistical analyses. Descriptive statistics on the total number of times that each participant spoke and the number of times that each participant's utterances were categorized as one of the levels was calculated for all tasks. This data then was merged with participants self-reported anxiety, comprehensibility, intelligibility, and fluency scores for the respective tasks in order to see if any patterns emerged regarding whether and how anxiety impacted the type of discourse that participants were producing.

Finally, participants' heart rate data was merged with the transcriptions and video-recordings of their conversations in order to determine how heart rate fluctuated in response to unfolding discourse. First, each participant's heart rate data -- tracked second-by-second using Polar OH1 heart rate monitors -- was overlayed onto the video recordings in order to be able to visualize increases and decreases in heart rate throughout the consensus-building activity. For each participant, moments of peaks (e.g., increases in heart rate due to linguistic breakdown) and lulls (e.g., decreases in heart rate due to lower-level discourse) in heart rate were identified and qualitatively analyzed within the context of the conversation in an effort to identify and understand the factors contributing to these fluctuations. Please find the results for this research question in Chapter 4: Results starting on page 121.

Research Question 5 (RQ5).

RQ5 explored participants' perceptions of the three learning environments and how they felt they impacted their language learning and anxiety. A main data set composed of qualitative semi-structured debriefing interviews conducted with 18 participants was used to answer this research question. As participation in the interviews was voluntary, the written responses to the debriefing questionnaire were used for those who did not partake in the interview.

First, all interviews were transcribed verbatim by the researcher so that they could be later coded using inductive thematic analysis, (i.e., "a method for identifying, analyzing, and reporting patterns (themes) within data [...] [and] describe[ing] your data in rich detail") (Braun & Clarke, 2006, p. 79). Following Braun and Clarke's (2006) guidelines for performing thematic analysis on qualitative data in psychology, five steps were followed when generating the themes that would be later applied to the transcribed data: (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, and (5) defining and naming themes.

To become familiar with the data, the researcher first transcribed verbatim all of participants' interviews. Then, the researcher immersed herself in the dataset by "actively" reading through all the transcriptions and taking notes simultaneously (i.e., "searching for meanings, patterns, and so on") (Braun & Clarke, 2006, p. 87). Next, using *MAXQDA*, a qualitative analysis software, the researcher generated initial codes for a subset of three interviews in the dataset. These initial codes were composed of short phrases that summarized what participants were saying in their interviews regarding the three learning environments.

Next, the researcher began to search for themes, by "sorting the potential codes into different themes, and collating all the relevant coded data extracts within the identified themes" (Braun & Clarke, 2006, p. 89). In order to do this, the researcher used *MAXQDA* to create a code map that separated similar codes into specific categories. Figure 24. shows an example of initial codes that were organized into different themes. 9 themes ultimately emerged from the initial coding. These themes were then named and defined (Table 6).

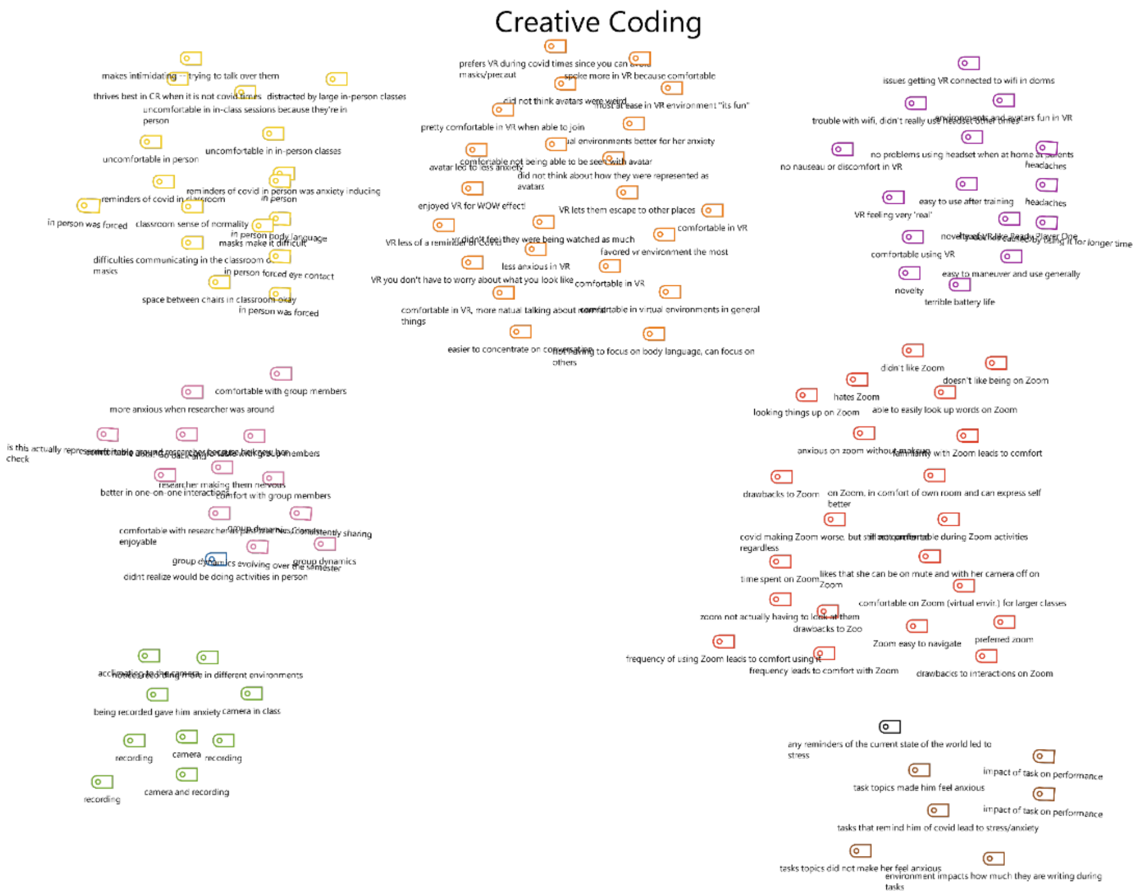


Figure 24. Initial codes organized into themes

Theme	Definition	Example
Mood	When a participant mentions being (un)comfortable, at ease, relaxed, anxious, etc. during any point of the study. This can be in any environment.	"I mean during the in-class sessions, I guess like – like I always felt a little more discomfort during the in-class sessions just because they're in person and like you actually get to talk to people"
VR Immersiveness & Enjoyability	When a participant mentions that VR is fun, enjoyable, entertaining, novel, etc. OR when a participant talks about the immersiveness of VR or how real it felt.	"– and I also enjoyed um - I really enjoyed VR cause there was sort of a sense like 'like ooo, ahh' like everywhere you look around, it was like 'oh this is fun!' And like it felt sort of like a game almost"
VR Usability	When a participant mentions that VR was either easy/hard to use or that they were comfortable using it (technologically speaking). When a participant talks about limitations of VR (e.g., wifi issues, battery, etc.)	"I don't know generally it was decently easy to maneuver and use generally yeah"
Group Dynamics	When a participant talks about the dynamics of their group or their interactions with the research assistantship. (e.g., I am comfortable with my group / I was nervous when the researcher was present).	"Yeah I felt pretty comfortable with them."
Recording	Any mention of being recorded or noticing a camera.	"oh I see this so I know that its being recorded or like something like that"
Perceptions of self/others	Anything referring to body language, eye contact, being seen by others or seeing others, or being represented by avatars	"I guess for the posture thing - like again like I guess its like a lot of body language stuff like knowing like I don't have to sit up straight or like I don't know like just like sit and just like - like look around and just like, just like be there and like only focus on like listening to what Nathan is saying and like potentially making a gesture back or something."
Zoom	When participants mention anything about Zoom (that does not fall into the Mood code). (e.g., I use Zoom X hours a day, I like being able to look things up on Zoom, etc.)	"even if we are talking in the break out groups and stuff, just being on Zoom in and of itself, I'm like 'god, like screw this'"
Classroom	When participants mention anything about the classroom (that does not fall into the Mood code). (e.g., covid precautions, easier to communicate in person)	"I think it was more of like the masks and everything. Because I feel like if we were in chairs, I think we would normally be that spread apart or just maybe a little bit closer to each other, but I think yeah it was more the masks"
Tasks	When participants talk about the tasks themselves or how they impacted/did not impact their performance	"It was the Oympic one as well as the one where we were like the people involved in the university, like more specifically the one where we were involved in the university cause that one like hit really close to home."

Table 6. Themes generated from initial coding

This new coding scheme was then piloted by having the main researcher and two research assistants independently code the three interviews using the nine themes provided. Upon comparing coding, initial agreement was 75.63%. Any instances of disagreement were discussed until agreement was reached and documented using memos in order to ensure systematic coding moving forward. Any clarifications needed regarding the definitions of codes were also made. Finally, all interviews were coded independently by the researcher and one research assistant. Upon comparing codes, agreement was found to be 79.83%, and any instances of disagreement were discussed until 100% agreement was reached.

Lastly, participants' presence scores were triangulated with their qualitative responses. In analyzing the presence data, participants' responses to the 8 questions were first scored with 0 or 1 based upon whether their response indicated presence in the VR. Participants scores for all questions were then added together to create a presence score for each participant during each VR task (ranging from 0-8). A simple linear regression model with self-reported anxiety as a dependent variable and presence score as an independent variable was run in order to see if the degree to which participants experienced presence impacted their self-reported anxiety during the VR tasks.

CHAPTER 4: RESULTS

RQ1: Relationship between Foreign Language Anxiety, Social Anxiety, and Participant Background

RQ1 aimed to examine the relationship between participant background (gender, onset age of learning French, substantial prior immersion experience, previous languages learned, and previous anxiety diagnoses), their self-assessed foreign language anxiety (FLA), their self-assessed social interaction anxiety, and their immersive tendencies at the onset of the study. Participants' scores from the Foreign Language Anxiety Questionnaire (FLAQ), Social Interaction Anxiety Scale (SIAS), Social Phobia Scale (SPS), and Immersive Tendencies Questionnaire (ITQ) are presented in Table 7. Pseudonyms are used for all participants.

Participant Pseudonym	***FLA*** *(27-108)*	***SIAS*** *(0-80)*	***SPS*** *(0-80)*	***Anxiety Group*** *(ANX+, ANX±, ANX-)*	***ITQ*** *(26-182)*
Jessica	69	44**	33*	ANX+	82
Nick	47	12	3	ANX-	63
Samantha	58	56**	54*	ANX+	94
Melanie	56	35*	40*	ANX+	76
Iris	57	19	8	ANX-	83
Rick	54	8	3	ANX-	100
Amanda	65	52**	17	ANX+	90
Rohan	60	10	3	ANX-	81
Mark	67	31	28*	ANX±	96
Talia	69	21	6	ANX±	86
Jacob	28	31	17	ANX-	100
Hashana	77	63**	52*	ANX+	95
Eric	81	5	14	ANX±	134
Riley	77.5	16	26*	ANX±	127
Mason	38	6	1	ANX-	127
Hannah	81	20	30*	ANX±	108
Mitchell	55	27	3	ANX-	102
Ella	83	41*	40*	ANX+	104
Nicole	58	20	13	ANX-	89
McKenzie	31	12	3	ANX-	93
Katie	90.5	68**	53*	ANX+	95
Selina	57	18	15	ANX-	127
Levi	45	21	5	ANX-	75
Lucia	84.5	44**	25*	ANX+	75
Martin	52	13	5	ANX-	91
Chris	43	6	0	ANX-	99
Stacey	55	12	19	ANX-	92
Scarlett	106	8	22	ANX±	113
Izabella	52	8	5	ANX-	92
Violet	76	48**	66*	ANX+	114
Leo	85	46**	40*	ANX+	125
Hudson	73	27	14	ANX±	124
Layla	59	26	22	ANX-	128
Brody	73	60**	31*	ANX+	90
Valerie	57	10	7	ANX-	104
Justin	58	19	4	ANX-	85
Morgan	56.5	19	9	ANX-	114
Ethan	76	19	18	ANX±	114
Mean	63.42	26.34	19.84	--	99.66
SD	16.63	17.79	17.28	--	17.59

Key: **: SIAS > 43 (indicates traditional social anxiety); *: SIAS > 32 (indicates social phobia), *: SPS > 24 (indicates social anxiety disorder).
Table 7. Participant FLA, SIAS, SPS, and ITQ scores

Participants' FLAQ baseline anxiety scores ranged from 28 - 106 out of 108 (M = 63.42, SD = 16.63), with higher scores indicating higher anxiety. To recall, a series of simple linear regression models were conducted to examine the impact of various background factors (e.g., the impact of gender on FLA scores) on foreign language anxiety and social anxiety. This revealed that male students scored lower than female students by 7.71-points on average (p = .16). Participants who had an earlier French onset learning age were also found to have significantly lower FLAQ than those who had begun learning French later, $F(1, 34) = 4.656$, $p = .038$, R^2 = .095, Cohen's d = .411 (small effect), suggesting that earlier onset learning does indeed contribute to lower anxiety in language learning. Moreover, participants who had substantial prior immersion experience in a Francophone country were found to score on average 6.80-points lower on the FLAQ than those who never went abroad, albeit this difference was not statistically significant (p = .26). It should be noted however that only 11 out of 38 participants had spent time abroad, so these results should be interpreted with caution. Participants who had been previously clinically diagnosed with an anxiety disorder were found to have significantly higher FLA by 13.39-points on average than those who had not, $F(1, 36) = 6.05$, $p < .05$, R^2 = .120, Cohen's d = .854 (medium effect), suggesting that FLA is indeed related to other types of social anxiety disorders. Lastly, participants who had previous experience with at least one foreign language aside from French scored on average 9.43 points lower on the FLAQ, albeit this difference was not statistically significant (p = .09).

Participants' SIAS scores ranged from 5 - 68 out of 80 (M = 26.34, SD = 17.79). SPS scores ranged from 0 - 66 out of 80 (M = 19.84, SD = 17.28). Male students were again found to score on average 5.40-points lower than female students on the SIAS, though this finding was not statistically significant (p = .357). However, male students had significantly lower SPS scores than female students by an average of 11.31-points, $F(1, 36) = 4.438$, $p < .05$, $R^2 = .085$, Cohen's d = .68 (medium effect). Unsurprisingly, participants who had received an official previous anxiety diagnosis were found to score on average 10.83 points higher on the SIAS (p =

.08). These same participants were also found to score significantly higher (20.33 points on average) on the SPS, $F(1, 36) = 15.96$, $p < .001$, $R^2 = .288$, Cohen's $d = 1.37$ (large effect).

Regarding the 3 anxiety groups (ANX+, ANX±, and ANX-) that were created using k-means clustering, 11 ANX+ participants were identified (9 females and 2 males), 8 ANX± participants were identified (4 females and 4 males), and 19 ANX- participants were identified (11 males and 8 females). This clustering pattern reiterates yet again that female students experience higher anxiety -- both self-reported FLA and social anxiety -- than their male counterparts.

Moreover, significant positive Pearson's correlations were found between SIAS and SPS scores ($r(36) = .80$, $p < .001$), SIAS and FLAQ scores ($r(36) = .39$, $p < .05$), and SPS and FLAQ scores ($r(36) = .56$, $p < .001$), indicating again a clear relationship between the degree to which participants experience foreign language anxiety and general social anxiety.

Finally, no significant relationships emerged between participants' ITQ scores and their FLAQ ($p = .16$), SIAS ($p = .360$), and SPS ($p = .507$) scores, indicating that participants' tendency to become immersed did not relate to the extent to which they experienced foreign language or social anxiety.

RQ2: The Impact of the Environment on Anxiety

RQ2 served to investigate the impact of the learning environment on (a) participants' self-reported anxiety and (b) physiological anxiety (measured via heart rate) while they were engaged in spontaneous interpersonal oral production to reach a consensus with the peers in their group.

RQ2a: *Self-reported Anxiety*

RQ2a specifically examined whether and how the environment impacted participants self-assessed anxiety. Participants' self-reported post-task anxiety ratings are presented in Figure 25.

Key: CR1 = classroom task 1; CR2 = classroom task 2; VR1 = virtual reality task 1; VR2 = virtual reality task 2; VR3 = virtual reality task 3; Z1 = Zoom task 1; Z2 = Zoom task 2; Z3 = Zoom task 3[5]; n/a = participant absent from class; blank = participant did not have option to complete task in that environment that semester
Figure 25: Self-reported anxiety scores across all six tasks

As this study was integrated into an existing French course, data is missing for participants who were absent from class during any days of data collection. 16 out of 38 participants attended all of their respective sessions for data collection. The means, SDs, and confidence intervals (CIs) for participants self-reported post-task anxiety scores are presented in Table 8.

[5] Spring 2021 participants completed an additional task in VR and Zoom (i.e., VR3 and Z3), since they were unable to complete any classroom tasks that semester.

Task	*Mean*	*SD*	*CI (Low.-Upp)*
CR1	21.7	7.91	18.5 - 25.0
CR2	19.1	5.10	16.9 - 21.2
VR1	22.4	7.13	20.0 - 24.7
VR2	20.5	5.81	18.6 - 22.4
VR3	20.8	7.10	16.5 - 25.1
Z1	21.9	6.89	19.7 - 24.2
Z2	20.8	6.98	18.5 - 23.1
Z3	20.0	7.50	15.5 - 24.5
ANX+	25.3	8.09	23.3 - 27.3
ANX±	22.7	4.95	21.3 - 24.1
ANX-	18.2	4.97	17.3 - 19.1

Table 8. Mean, SDs, CIs of self-reported anxiety data.

Participants as a whole self-reported the highest anxiety during the VR1 task (*M* = 22.4, *SD* = 7.13), followed by the Z1 (*M* = 21.9, *SD* = 6.89), CR1 (*M* = 21.7, *SD* = 7.91), VR3 (*M* = 20.8, *SD* = 7.10) and Z2 (*M* = 20.8, *SD* = 6.98), VR2 (*M* = 20.5, *SD* = 5.81), Z3 (*M* = 20.0, *SD* = 7.50), and CR2 (*M* = 19.1, *SD* = 5.10) tasks. ANX+ participants (*M* = 25.3, *SD* = 8.09) also self-reported higher anxiety than ANX± (*M* = 22.7, *SD* = 4.95) and ANX- (*M* = 18.2, *SD* = 4.97).

A linear model including participant as a random factor and anxiety group (ANX+, ANX±, and ANX-) as a fixed factor was conducted to examine the impact of environment on post-task self-reported anxiety scores. Anxiety group was included in the model instead of participants' numeric baseline anxiety score, as this measure of anxiety is less susceptible to being influenced by outliers. The model output, pairwise comparisons, effect sizes (Cohen's *d*), and confidence intervals are reported in Table 9. For any comparisons across tasks (e.g., VR1, VR2, CR1, Z2, etc.), effect sizes were interpreted according to Plonsky and Oswald's (2014) recommendation for SLA studies that contain within-group contrasts (i.e., .60 = generally small effect, 1.00 = medium effect, and 1.40 = large effect). For effect sizes of participant group (i.e., ANX+, ANX±, ANX-), results were interpreted following recommendation for between-group comparisons (i.e., .40 = generally small, .70 = medium, 1.00 = large).

Linear Model Output						*Pairwise Comparisons, Cohens d, & CIs*					
Fixed Effect	**Est.**	**SE**	**DF**	**t-value**	**p-value**	***Pair. Comp.***	**Est.**	**p-value**	**Coh. *d***	**CIs**	
										Low.	**Upp.**
Inter. *(CR1)*	18.498	1.388	73.857	13.326	<.001*	*CR1 / VR1*	-.490	.999	.094	-3.97	2.98
CR2	-1.426	1.297	148.126	-1.100	.273	*CR1 / Z1*	-.281	1.000	.027	-3.73	3.17
VR1	.491	1.130	148.439	.434	.665	*CR2 / VR2*	-1.292	.971	.253	-5.18	2.60
VR2	-.134	1.177	150.744	-.113	.909	*CR2 / Z2*	-.046	1.000	.270	-4.00	3.90
VR3	-.630	1.652	157.150	-.381	.703	*VR1 / Z1*	.209	1.000	.071	-2.86	3.28
Z1	.281	1.120	150.344	.251	.802	*VR2 / Z2*	1.245	.945	-.047	-2.09	4.58
Z2	-1.380	1.177	151.213	-1.173	.243	*VR3 / Z3*	.840	.999	.110	-4.44	6.12
Z3	-1.470	1.606	156.497	-.915	.362	*CR1 / CR2*	1.426	.956	-.391	-2.56	5.41
ANX+	7.514	1.868	35.163	4.022	<.001*	*VR1 / VR2*	.625	.999	-.292	-2.63	3.88
ANX±	5.077	2.097	36.289	2.421	<.05*	*VR2 / VR3*	.496	1.000	.049	-4.16	5.16
						Z1 / Z2	1.661	.726	-.159	-1.46	4.78
						Z2 / Z3	.090	1.000	-.113	-4.39	4.57
						ANX- / ANX+	-7.510	<.001*	1.129 (L)	-12.10	-2.94*
						ANX- / ANX±	-5.080	.052*	.907 (M)	-10.20	.05
						ANX+ / ANX±	2.44	.547	-.374 (S)	3.20	8.08

Model = lmerTest:: lmer(anxiety~environment + anxietygroup + (1|participant), data = data)
Effect Size: S = small effect size; M = medium effect size; L = large effect size
Table 9. Model output for environment on anxiety with pairwise comparisons and effect sizes

Pairwise comparisons revealed that participants' self-reported anxiety was fairly stable across the three environments, suggesting that participants as a whole did not necessarily feel less anxious in one environment compared to the other. However, participants did report lower anxiety within each environment over time (CR1: 21.7, CR2: 19.1; VR1: 22.4, VR2: 20.5; VR3: 20.8; Z1: 21.9, Z2: 20.8, Z3: 20.0). Although these slight reductions could indicate that participants became more comfortable within each environment throughout the semester, no significant differences or notable effect sizes emerged. Regarding the different anxiety groups, ANX- participants reported overall that their anxiety was significantly lower than that of ANX+ participants by 7.510 points ($p < .001$) [-12.10, -2.94] (large effect) and that of ANX± participants by 5.080 points ($p = .052$) [-10.20, .05] (medium effect). Finally, ANX± participants reported that their anxiety was lower than that of ANX+ participants by 2.440 points (small effect).

As participants were expected to respond to the various learning environments differently based on their baseline foreign language anxiety, descriptive data of each anxiety group's self-reported anxiety scores were examined. The means, SDs, and confidence intervals (CIs) for each anxiety group's self-reported post-task anxiety scores are presented in Table 10. Since breaking participants into their different anxiety groups resulted in smaller sample sizes (ANX-: $n = 19$; ANX±: $n = 8$; ANX+: $n = 11$), no linear models were conducted on this self-reported anxiety data.

	Task								
Anxiety Group		CR1	CR2	VR1	VR2	VR3	Z1	Z2	Z3
ANX-	*Mean*	17.6	17.3	18.9	18.7	20.0	19.1	16.6	17.2
	SD	5.72	4.57	5.18	4.16	5.60	5.77	4.03	6.13
	CIs	14.3 - 20.9	14.7 - 19.9	16.4 - 21.4	16.7 - 20.7	13.0 - 27.0	16.3 - 21.9	14.6 - 18.5	9.64 - 24.9
ANX±	*Mean*	29.5	23.0	24.4	22.2	19.8	25.1	21.9	18.6
	SD	4.95	N/A	2.70	3.97	6.18	5.46	5.05	2.19
	CIs	17.2 - 41.8	N/A [6]	22.1 - 26.7	18.8 - 25.5	12.1 - 27.4	20.6 - 29.7	17.6 - 26.1	15.9 - 21.3
ANX+	*Mean*	27.9	23.8	26.5	24	23.3	24.5	24.7	26
	SD	7.08	4.03	8.59	9.42	11.6	8.14	8.31	13
	CIs	21.9 - 33.8	20.4 - 27.1	20.8 - 32.3	17.7 - 30.3	-5.46 - 52.1	19.0 - 30.0	19.1 - 30.3	-6.29 - 58.3

Table 10. Means, SDs, and CIs of anxiety group's self-reported anxiety data

Concerning ANX- participants, they self-reported the lowest anxiety in the Z2 task, followed by Z3, CR2, CR1, VR2, VR1, Z1, and VR3, suggesting that these participants were the least anxious during *Zoom* and classroom tasks. This is not surprising, since VR can add extra technological challenges and since these participants' anxiety levels were not necessarily expected to benefit from being in virtual spaces compared to those of their more anxious peers. Regarding ANX± students, they self-reported the lowest anxiety in the Z3 task, followed by VR3, Z2, VR2, CR2, VR1, Z1, and CR1 which could indicate that these participants were less anxious in virtual spaces than in the classroom. Moreover, participants were overall less anxious in *Zoom* than in VR, which could be attributed to the fact that students have been using *Zoom* constantly since the start of the COVID-19 pandemic. For these ANX± participants, self-reported anxiety also decreased in each environment over time which could point to the fact that they become more comfortable as the semester progressed. In terms of ANX+ participants, they self-reported the lowest anxiety in the VR3 task, followed by CR2, VR2, Z1, Z2, Z3, VR1, and CR1. This pattern could suggest that participants were the least anxious in VR once they had more

[6] Only one ANX± participant attended the CR2 task

time to become accustomed to using it. Moreover, these participants were also fairly comfortable on *Zoom*, although their anxiety increased in this environment over the course of the semester, which is the opposite of what we would expect to see. Finally, for the classroom tasks, ANX+ participants became more comfortable with them throughout the semester.

RQ2b*: *Heart Rate

In order to measure anxiety physiologically, participants' heart rate was collected during all data collection sessions. The baseline HR, minimum HR, maximum HR, mean, median, and SD for all participants' heart rate data are presented in Table 11.

Session	Baseline HR	Min HR	Max HR	Mean	Median	SD
CR1	81.2	64.2	107.0	82.6	83.9	10.3
CR2	83.9	65.8	116.0	86.7	86.4	14.3
VR1	78.5	62.9	84.7	72.1	68.6	7.68
VR2	83.7	66.7	102.0	82.3	81.2	8.68
VR3	81.6	78.9	78.9	78.9	78.9	5.26
Z1	79.7	59.7	103.0	79.2	75.1	11.6
Z2	79.5	57.6	102.0	78.0	76.1	13.3
Z3	77.0	69.8	78.6	74.2	74.2	6.26
ANX+	83.2	64.3	103.0	80.0	79.4	9.52
ANX±	82.2	78.2	116.0	89.8	86.9	12.2
ANX-	79.6	57.6	97.5	77.3	76.6	10.4

Table 11. Baseline HR, min HR, max HR, mean, median, and SD for each task in beats per minute

Participants as a whole had the lowest HR during the VR1 task (*M* = 72.1, *SD* = 7.68), followed by the Z3 (*M* = 74.2, *SD* = 6.26), Z2 (*M* = 78.0, *SD* = 13.3), VR3 (*M* = 78.9, *SD* = 5.26), Z1 (*M* = 79.2, *SD* = 11.6), VR2 (*M* = 82.3, *SD* = 8.68), CR1 (*M* = 82.6, *SD* = 10.3), and CR2 (*M* = 86.7, *SD* = 14.3) tasks. ANX± participants had the highest HR (*M* = 89.8, *SD* = 12.2), followed by their ANX+ (*M* = 80.0, *SD* = 9.52) and ANX- (*M* = 77.3, *SD* = 10.4) peers.

These descriptive statistics indicate that participants were the least physiologically anxious during virtual tasks. Their HR was also the least varied during VR tasks. Lastly, participants experienced an *increase* from their baseline HR during both classroom tasks (CR1: 1.4 bpm increase; CR2: 2.8 bpm increase). However, their HR *decreased* from their baseline in all virtual tasks (VR1: 6.4 bpm decrease; VR2: 1.4 bpm decrease; VR3: 2.7 bpm decrease; Z1: .5 bpm decrease; Z2: 1.5 bpm decrease; Z3: 2.8 bpm decrease). Moreover, when comparing participants' max heart rate to their baseline, participants had an *increase* of 25.8 bpm in CR1 and 32.1 bpm in CR2. Similarly, for *Zoom* tasks, they had an increase of 23.3 bpm in Z1, 33.8 bpm in Z2, and 1.6 bpm in Z3. However, in VR, students had a smaller *increase* of 6.1 bpm in VR1 and 18.3 bpm in VR2, yet a *decrease* of -2.4 bpm in VR3, suggesting that they were most physiologically at ease in VR.

A linear model including participant as a random factor and anxiety group (ANX+, ANX±, and ANX-) as a fixed factor was conducted to examine the impact of environment on HR. The model output, pairwise comparisons, effect sizes (Cohen's *d*), and confidence intervals are reported in Table 12.

Linear Model Output						***Pairwise Comparisons, Cohens d, & CIs***					
Fixed Effect	**Est.**	**SE**	**DF**	**t-value**	**p-value**	***Pair. Comp.***	**Est.**	**p-value**	**Coh. *d***	**CIs**	
										Low.	**Upp.**
Inter. *(CR1)*	80.586	2.479	47.363	32.508	<.001*	*CR1 / VR1*	10.550	.019*	-1.118 (M)	1.042	20.06*
CR2	4.248	3.186	60.487	1.333	.187	*CR1 / Z1*	5.771	.377	-.310	-2.538	14.08
VR1	-10.558	3.013	61.700	-3.502	<.001*	*CR2 / VR2*	6.039	.662	-.381	-4.871	16.95
VR2	-1.790	3.023	61.596	-.592	.556	*CR2 / Z2*	9.212	.227	-.630 (S)	-2.487	20.91
VR3	-13.378	8.794	62.084	-1.521	.133	*VR1 / Z1*	-4.779	.777	-.690 (S)	-14.438	4.88
Z1	-5.771	2.635	59.946	-2.190	.032*	*VR2 / Z2*	3.174	.985	-.391	-7.860	14.21
Z2	-4.964	3.232	62.827	-1.536	.130	*VR3 / Z3*	-.388	1.000	.751 (S)	-31.641	30.86
Z3	-12.990	6.424	65.901	-2.022	.047*	*CR1 / CR2*	-4.248	.885	.348	-14.301	5.80
ANX+	3.434	3.487	21.422	.981	.337	*VR1 / VR2*	-8.760	.166	1.245 (M)	-19.223	1.70
ANX±	14.540	4.168	22.120	3.489	.002*	*VR2 / VR3*	11.588	.891	.392	-16.152	39.33
						Z1 / Z2	-.807	1.000	-.098	-10.958	9.34
						Z2 / Z3	8.026	.926	-.298	-12.774	28.83
						ANX- / ANX+	-3.42	.599	.266	-12.3	5.434
						ANX- / ANX±	-14.54	.006*	1.158 (L)	-25.1	-3.945*
						ANX+ / ANX±	-11.12	.072	-.917 (L)	-23.1	.857

Model = lmerTest:: lmer(HR~environment + anxietygroup + (1|participant), data = data)
Effect Size: S = small effect size; M = medium effect size; L = large effect size
Table 12. Model output for environment on HR with pairwise comparisons and effect sizes

Pairwise comparisons revealed that participants' heart rate was significantly lower by 10.550 bpm during the VR1 task compared to the CR1 task [1.042, 20.06] (medium effect). Albeit not significant, participants also had lower heart rate during the Z1 task compared to the CR1 task by 5.771 bpm, lower HR in the VR2 task compared to the CR2 task by 6.039 bpm, lower HR during the Z2 task compared to the CR2 task by 9.212 bpm (small effect). In terms of the two virtual environments, participants had lower HR in VR1 compared to Z1 task by 4.779 bpm (small effect), but higher HR in VR2 compared to Z2 by 3.174 bpm and in VR3 compared to Z3 by .388 bpm (small effect).

When comparing how HR changed over the course of the semester, participants' HR increased for classroom tasks by 4.248 bpm. For VR tasks, it increased from VR1 to VR2 by 8.760 bpm (medium effect), but then decreased from VR2 to VR3 by 11.588 bpm. For Zoom tasks, participants' HR decreased continuously, though no effect sizes emerged.

Pairwise comparisons also revealed a significant difference in HR between ANX- and ANX± participants (p = .006) [-25.1, -3.945] (medium effect), with ANX± having higher HR. Surprisingly, ANX± participants also had a higher HR than their ANX+ peers (large effect). No significant differences or effect sizes emerged between ANX- and ANX+ participants.

As participants were expected to respond to the various learning environments differently based on their baseline foreign language anxiety, descriptive data of each anxiety group's HR data were also examined. The baseline HR, minimum HR, maximum HR, mean, median, and SD for each session for each participant group (ANX-, ANX+, ANX±) are presented in Table 13. Since breaking participants into their different anxiety groups again resulted in smaller sample sizes, no linear models were conducted on this self-reported anxiety data.

Participant Group	Session	Baseline HR	Min HR	Max HR	Mean	Median	SD
ANX-	CR1	81.5	66	97	80.8	79.8	5.26
	CR2	83.4	70.6	95.6	82.8	82.6	4.26
	VR1	76.8	59.3	90.1	71.2	70.9	5.75
	VR2	81.1	66.8	98.4	80.4	80.0	5.40
	VR3	--	--	--	--	--	--
	Z1	77.4	59.8	94.9	75.3	75.4	6.93
	Z2	75.8	59	89.6	71.2	70.6	5.58
	Z3	75.1	60	86	69.8	69.0	5.12
ANX±	CR1	76.5	69	127	107.0	110	9.61
	CR2	72.8	63	133	116.0	117	10.0
	VR1	84.5	64.5	104	82.4	82.5	6.90
	VR2	91.2	72	108	90.3	89.5	6.57
	VR3	81.6	67	100	78.9	78	5.26
	Z1	80.5	69.5	107	84.9	84.8	6.60
	Z2	83.7	79.5	112	95.6	96	7.10
	Z3	78.9	66	95	78.6	79	5.32
ANX+	CR1	81.3	64.8	100	83.5	83.3	5.35
	CR2	99.1	78	108	88.2	88	4.75
	VR1	78.5	52	85	67.2	67.7	6.70
	VR2	86.8	70	93.5	82.0	82	3.93
	VR3	--	--	--	--	--	--
	Z1	83.7	70.8	96.8	82.4	81.8	4.89
	Z2	83.0	66	96.7	77.7	77	5.05
	Z3	--	--	--	--	--	--

Table 13. Baseline HR, min HR, max HR, mean, median, and SD for each task in beats per minute by anxiety group

Concerning ANX- participants, their heart rate was lowest in the Z3 task (*M* = 69.8, *SD* = 5.12), followed by Z2 (*M* = 71.2, *SD* = 5.58) and VR1 (*M* = 71.2, *SD* = 5.75), Z1 (*M* = 75.3, *SD* = 6.93), VR2 (*M* = 80.4, *SD* = 5.40), CR1 (*M* = 80.8, *SD* = 5.26), CR2 (*M* = 82.8, *SD* = 4.26). This indicates that, physiologically speaking, ANX- participants were most comfortable in the Zoom environment, followed by VR and then the classroom. They also became more relaxed throughout the semester in both the Zoom and classroom environment, but less relaxed in the VR environment. ANX- participants' HR also decreased from their baseline for all tasks (CR1: .7 bpm; CR2: .6 bpm; VR1: 5.6 bpm; VR2: .7 bpm; Z1: 2.1 bpm; Z2: 4.6 bpm; Z3: 5.3 bpm). ANX- participants also had the highest maximum HR during the VR2 task (98.4 bpm), followed by the CR1 task (97 bpm), the CR2 task (95.6 bpm), the Z1 task (94.9 bpm), the VR1 task (90.1 bpm), the Z2 task (89.6) and finally the Z3 task (86 bpm), indicating again that they were more at ease in the Zoom environment, followed by VR and the classroom.

For ANX± participants, their heart rate was also lowest during the Z3 task (*M* = 78.6, *SD* = 5.32), followed by VR3 (*M* = 78.9, *SD* = 5.26), VR1 (*M* = 82.4, *SD* = 6.90), Z1 (*M* = 84.9, *SD* = 6.60), VR2 (*M* = 90.3, *SD* = 6.57), Z2 (*M* = 95.6, *SD* = 7.10), CR1 (*M* = 107.0, *SD* = 9.61), and CR2 (*M* = 116.0, *SD* = 10.0). This indicates that ANX± were physiologically the most at ease during VR tasks, followed by Zoom, and lastly the classroom. Their heart rate also decreased overall in virtual environments throughout the semester but increased in the classroom. Lastly ANX± participants' HR *decreased* from their baseline for all VR tasks and the third Zoom task (VR1: 2.1 bpm; VR2: .9 bpm; VR3: 2.7 bpm; Z3: .3 bpm) but *increased* from their baseline for the rest of the tasks (CR1: 30.5 bpm; CR2: 43.2 bpm; Z1: 4.4 bpm; Z2: 11.9). Lastly, ANX± participants had the highest maximum HR during the CR2 task (133 bpm), followed by the CR1 task (127 bpm), the Z2 task (112 bpm), the VR2 task (108 bpm), the Z1 task (107 bpm), the VR1 task (104), the VR3 task (100 bpm) and finally the Z3 task (95 bpm), indicating again that they were more at ease in the VR environment, followed by Zoom and the classroom.

Finally, ANX+ participants' heart rate was lowest during the VR1 tasks (*M* = 67.2, *SD* = 6.70), followed by Z2 (*M* = 77.7, *SD* = 5.05), VR2 (*M* = 82.0, *SD* = 3.93), Z1 (*M* = 82.4, *SD* = 4.89), CR1 (*M* = 83.5, *SD* = 5.35), and CR2 (*M* = 88.2, *SD* = 4.75). This indicates that, similar to their ANX± peers, ANX+ participants were physiologically the least anxious during VR tasks, followed by Zoom, and lastly the classroom. However, while their heart rate decreased over time for Zoom and classroom tasks, it increased for VR tasks. ANX+ participants' HR also decreased from their baseline for all tasks -- aside from CR1 (2.2 bpm increase) -- (CR2: 10.9 bpm; VR1:

11.3 bpm; VR2: 4.8 bpm; Z1: 1.3 bpm; Z2: 5.3 bpm). Finally, ANX+ participants had the highest maximum HR during the CR2 task (108 bpm), followed by the CR1 task (100 bpm), the Z1 task (96.8 bpm), the Z2 task (96.7 bpm), the VR2 task (93.5 bpm), and the VR1 task (85), indicating again that they were more at ease in the VR environment, followed by Zoom and the classroom.

RQ3: Impact of Environment and Anxiety on Oral Production

RQ3 aimed to examine the impact of the environment and self-assessed anxiety on participants' comprehensibility, intelligibility, and fluency as well as the relationship between the three speech measures.

Comprehensibility

Participants' *comprehensibility* scores for each task are shown in Figure 26. Participants' scores ranged from 3.11 to 9 out of 9, with a higher score indicating better comprehensibility.

Key: CR1 = classroom task 1; CR2 = classroom task 2; VR1 = virtual reality task 1; VR2 = virtual reality task 2; VR3 = virtual reality task 3; Z1 = Zoom task 1; Z2 = Zoom task 2; Z3 = Zoom task 3; n/a = participant absent from class; blank = participant did not have option to complete task in that environment that semester

Figure 26: Comprehensibility scores across all six tasks

The means, SDs, and confidence intervals (CIs) for participants' comprehensibility scores are presented in Table 14.

Task	***Mean***	***SD***	***CI** (Low.-Upp)*
CR1	6.23	1.34	5.65 - 6.81
CR2	6.69	1.23	6.08 - 7.31
VR1	7.47	1.11	7.08 - 7.87
VR2	7.29	1.13	6.87 - 7.71
VR3	7.97	.601	7.59 - 8.35
Z1	7.25	1.22	6.84 - 7.66
Z2	7.70	1.08	7.30 - 8.10
Z3	7.87	.624	7.45 - 8.29
ANX+	7.18	1.43	6.79 - 7.56
ANX±	7.29	1.20	6.89 - 7.68
ANX-	7.32	1.09	7.10 - 7.53

Table 14. Mean, SDs, and CIs of comprehensibility scores

Descriptively speaking, participants as a whole were most comprehensible during the VR3 task (*M* = 7.97, *SD* = .601), followed by the Z3 (*M* = 7.87, *SD* = .624), Z2 (*M* = 7.70, *SD* = 1.08), VR1 (*M* = 7.47, *SD* = 1.11), VR2 (*M* = 7.29, *SD* = 1.13), Z1 (*M* = 7.25, *SD* = 1.22), CR2 (*M* = 6.69, *SD* = 1.23), and CR1 (*M* = 6.23, SD = 1.34) tasks. ANX- participants were the most comprehensible (*M* = 7.32, *SD* = 1.09), followed by their ANX± (*M* = 7.29, *SD* = 1.20) and ANX+ peers (*M* = 7.18, *SD* = 1.43).

A linear model including participant as a random factor and anxiety group (ANX+, ANX±, and ANX-) as a fixed factor was conducted to examine the impact of environment on comprehensibility scores. The model output, pairwise comparisons, effect sizes (Cohen's *d*), and confidence intervals are reported in Table 15.

Linear Model Output						***Pairwise Comparisons, Cohens d, & CIs***					
Fixed Effect	**Est.**	**SE**	**DF**	**t-value**	**p-value**	***Pair. Comp.***	**Est.**	**p-value**	**Coh. *d***	**CIs**	
										Low.	**Upp.**
Inter. *(CR1)*	6.652	.265	56.644	25.118	<.001*	*CR1 / VR1*	-1.004	<.001*	1.026 (M)	-1.548	-.459*
CR2	.439	.204	148.507	2.153	.033*	*CR1 / Z1*	-.700	.003*	.805 (S)	-1.242	-.158*
VR1	1.004	.177	148.965	5.668	<.001*	*CR2 / VR2*	-.390	.499	.514 (S)	-.996	.216
VR2	.829	.182	149.592	4.545	<.001*	*CR2 / Z2*	-.659	.028*	.888 (S)	-1.277	-.041*
VR3	.911	.254	154.636	3.581	<.001*	*VR1 / Z1*	.303	.517	.188	-.174	.781
Z1	.700	.176	149.904	3.972	<.001*	*VR2 / Z2*	-.269	.754	-.354	-.788	.250
Z2	1.098	.184	150.154	5.964	<.001*	*VR3 / Z3*	.063	1.000	.163	-.765	.892
Z3	.848	.261	153.709	3.243	.001*	*CR1 / CR2*	-.439	.388	.356	-1.065	.188
ANX+	-.262	.384	34.323	-.682	.450	*VR1 / VR2*	.175	.963	-.161	-.329	.678
ANX±	-.330	.429	35.138	-.768	.448	*VR2 / VR3*	-.082	1.000	.672 (S)	-.800	.635
						Z1 / Z2	-.398	.206	.388	-.887	.093
						Z2 / Z3	.250	.966	.173	-.482	.981
						ANX- / ANX+	.262	.775	-.115	-.677	1.20
						ANX- / ANX±	.330	.725	-.027	-.720	1.38
						ANX+ / ANX±	.068	.987	-.082	-1.088	1.22

Model = lmerTest:: lmer(comprehensibility~environment + anxietygroup + (1|participant), data = data)

Effect Size: S = small effect size; M = medium effect size

Table 15. Model output for environment and anxiety on comprehensibility with pairwise comparisons and effect sizes

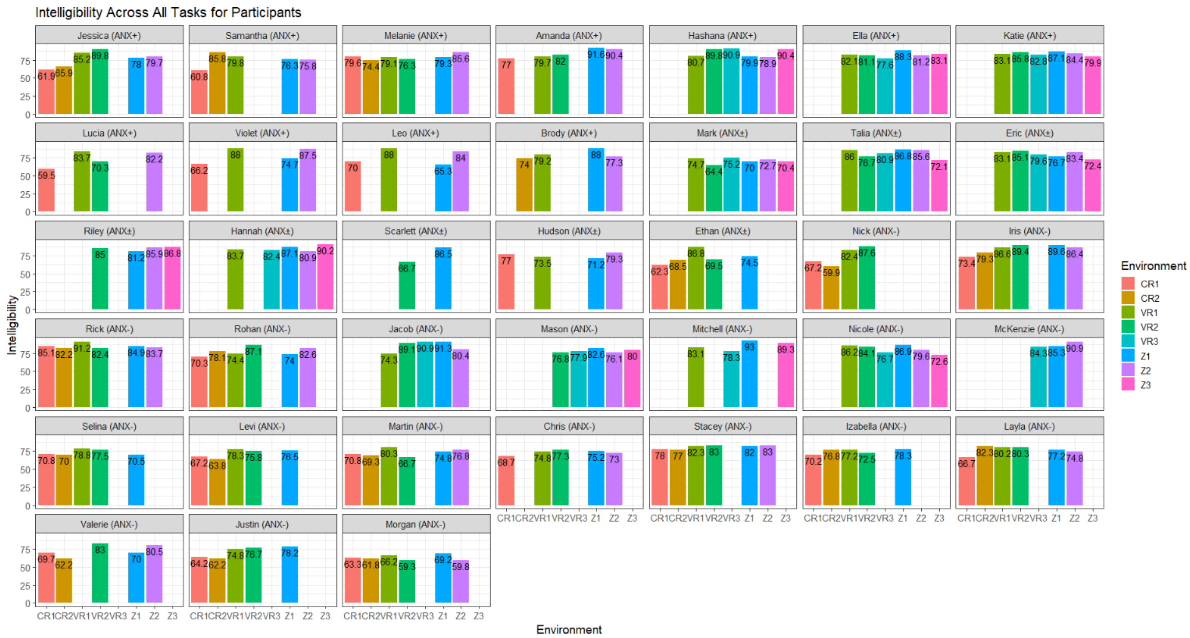
Pairwise comparisons revealed that raters considered speakers to be significantly more comprehensible by 1.004 points during the VR1 task compared to the CR1 task [-1.548, -.459] (medium effect). Likewise, participants were also significantly more comprehensible during the Z1 task compared to the CR1 task by .700 points [-1.242, -.158] (small effect). Participants were also more comprehensible, albeit not significantly, in the VR2 task compared to the CR2 task by .390 points (small effect), and significantly more comprehensible in the Z2 task compared to the CR2 task by .659 points (small effect). In terms of the two virtual environments, participants scored higher in the VR1 task compared to the Z1 task by .303 points and in the VR3 task compared to the Z3 task by .063 points. However, participants were more comprehensible during the Z2 task than in the VR2 task by .269 points. No significant differences or effect sizes emerged between the two virtual environments.

When comparing how comprehensibility changed over the course of the semester, participants were found to slightly improve in each environment. Specifically, for classroom tasks, participants performed .439 points higher in CR2 than in CR1. For Zoom tasks, participants were more comprehensible by .398 points in Z2 compared to Z1 and by .250 points in Z3 compared to Z2. The pattern for VR tasks was a bit different, with participants being .175 points less comprehensible in VR2 compared to VR1, *but* .082 points more comprehensible in VR3 compared to VR2 (small effect).

Finally, ANX- were only .330 points and .262 points more comprehensible than their ANX± and ANX+ peers respectively. This is surprising, as the preliminary study found ANX- participants to be significantly more comprehensible than those that were ANX+ (large effect).

Intelligibility

Participants' *intelligibility* scores for each task are shown in Figure 27. Participants' scores ranged from 59.33 to 93 out of 100, with a higher score indicating higher intelligibility.



Key: CR1 = classroom task 1; CR2 = classroom task 2; VR1 = virtual reality task 1; VR2 = virtual reality task 2; VR3 = virtual reality task 3; Z1 = Zoom task 1; Z2 = Zoom task 2; Z3 = Zoom task 3; n/a = participant absent from class; blank = participant did not have option to complete task in that environment that semester

Figure 27: Intelligibility scores across all six tasks

The means, SDs, and confidence intervals (CIs) for participants' intelligibility scores are presented in Table 16.

Task	***Mean***	***SD***	***CI*** *(Low.-Upp)*
CR1	69.6	6.51	66.7 - 72.4
CR2	71.9	8.12	67.8 - 75.9
VR1	80.8	5.27	79.0 - 82.7
VR2	79.0	8.17	76.0 - 82.1
VR3	81.5	5.16	78.2 - 84.7
Z1	80.1	7.29	77.6 - 82.5
Z2	80.7	6.10	78.5 - 83.0
Z3	80.7	7.85	75.4 - 85.9
ANX+	80.0	7.79	77.9 - 82.1
ANX±	78.3	7.35	75.9 - 80.7
ANX-	77.3	8.04	75.6 - 78.9

Table 16. Means, SDs, and CIs of intelligibility scores

Descriptively speaking, participants as a whole were most intelligible during the VR3 task (*M* = 81.5, *SD* = 5.16), followed by the VR1 (*M* = 80.8, *SD* = 5.27), Z3 (*M* = 80.7, *SD* = 7.85), Z2 (*M* = 80.7, *SD* = 6.10), Z1 (*M* = 80.1, *SD* = 7.29), VR2 (*M* = 79.0, *SD* = 8.17), CR2 (*M* = 71.9, *SD* = 8.12), and CR1 (*M* = 69.6, SD = 6.51) tasks. Contrary to what was found with comprehensibility, ANX+ participants were the *most* intelligible (*M* = 80.0, *SD* = 7.79), followed by their ANX± (*M* = 78.3, *SD* = 7.35) and ANX- peers (*M* = 77.3, *SD* = 8.04).

A linear model including participant as a random factor and anxiety group (i.e., ANX-, ANX+, and ANX±) as a fixed factor was conducted to examine the impact of environment on intelligibility scores. The model output, pairwise comparisons, and effect sizes (Cohen's *d*) and confidence intervals are reported in Table 17.

Linear Model Output						Pairwise Comparisons, Cohens d, & CIs					
Fixed Effect	**Est.**	**SE**	**DF**	**t-value**	**p-value**	**Pair. Comp.**	**Est.**	**p-value**	**Coh. *d***	**CIs**	
										Low.	**Upp.**
Inter. *(CR1)*	70.015	1.547	107.494	45.271	<.001*	*CR1 / VR1*	-10.456	<.001*	1.929 (L)	-15.160	-5.747*
CR2	2.384	1.765	151.241	1.351	.179	*CR1 / Z1*	-9.535	<.001*	1.500 (L)	-14.210	-4.861*
VR1	10.456	1.531	152.400	6.831	<.001*	*CR2 / VR2*	-6.591	.004*	.871 (M)	-11.820	-1.364*
VR2	8.975	1.573	154.216	5.705	<.001*	*CR2 / Z2*	-7.469	<.001*	1.272 (M)	-12.780	-2.158*
VR3	9.548	2.152	167.910	4.436	<.001*	*VR1 / Z1*	.921	.997	.109	-3.220	5.058
Z1	9.535	1.519	154.873	6.278	<.001*	*VR2 / Z2*	-.878	.999	-.236	-5.360	3.607
Z2	9.853	1.584	155.713	6.220	<.001*	*VR3 / Z3*	.449	1.000	.122	-6.680	7.681
Z3	9.049	2.219	165.803	4.077	<.001*	*CR1 / CR2*	-2.384	.878	.317	-7.810	3.044
ANX+	1.811	1.807	34.453	1.002	.323	*VR1 / VR2*	1.481	.967	-.265	-2.880	5.838
ANX±	-.545	2.047	36.580	-.266	.792	*VR2 / VR3*	-.573	1.000	.335	-6.700	5.557
						Z1 / Z2	-.318	1.000	.089	-4.570	3.930
						Z2 / Z3	.804	.999	.000	-5.480	7.090
						ANX- / ANX+	-1.811	.581	.440 (S)	-6.240	2.610
						ANX- / ANX±	.545	.962	.127	-4.460	5.550
						ANX+ / ANX±	2.355	.552	.223	-3.140	7.850

Model = lmerTest:: lmer(intelligiblity~environment + anxietygroup + (1|participant), data = data)
Effect Size: S = small effect size; M = medium effect size; L = large effect size
Table 17. Model output for environment and anxiety on intelligibility with pairwise comparisons and effect sizes

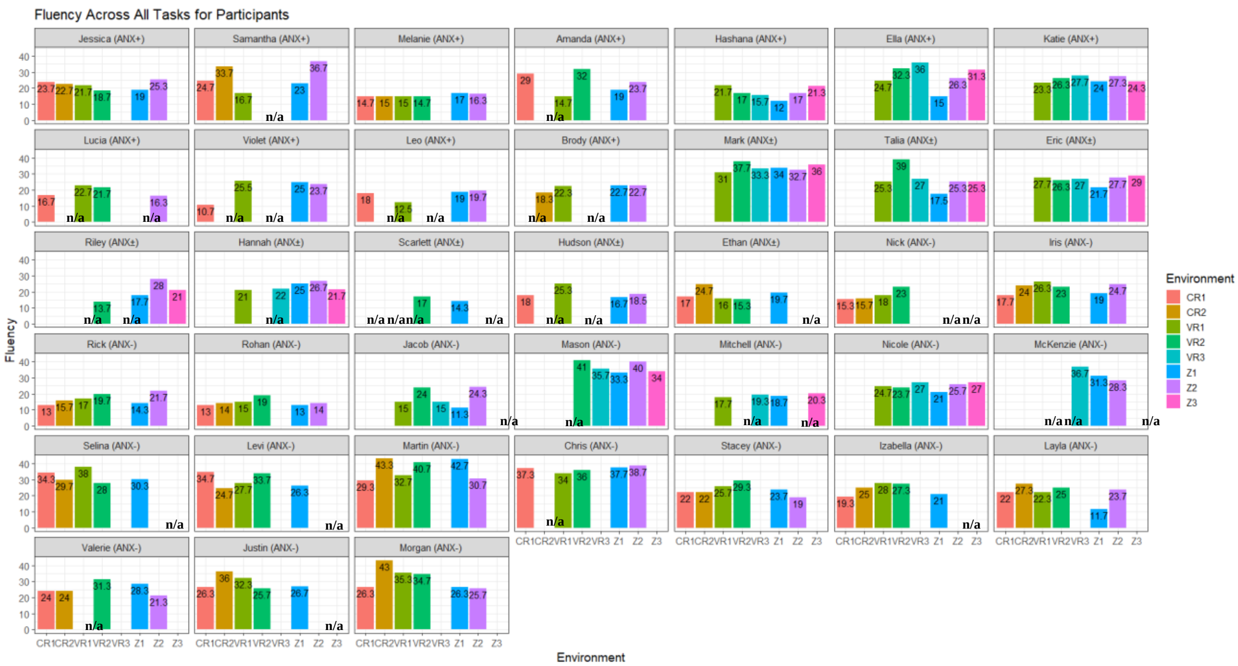
Similarly to comprehensibility, pairwise comparisons revealed that raters considered speakers to be significantly more intelligible by 10.456 points during the VR1 task compared to the CR1 task [-15.160, -5.747] (large effect). Likewise, participants were also significantly more intelligible during the Z1 task compared to the CR1 task by 9.535 points [-14.210, -4.861] (large effect). Participants were also significantly more intelligible in the VR2 task compared to the CR2 task by 6.591 points [-11.820, -1.364] (medium effect) and in the Z2 task compared to the CR2 task by 7.469 points [-12.780, -2.158] (medium effect). In terms of the two virtual environments, the results mirrored what was found with comprehensibility scores. Participants were again more intelligible in the VR1 task compared to the Z1 task by .921 points and in the VR3 task compared to the Z3 task by .449 points. However, participants were more intelligible during the Z2 task than in the VR2 task by .878 points. No significant differences or effect sizes emerged between the two virtual environments.

When comparing how intelligibility changed over the course of the semester, participants were found to slightly improve in each environment. Specifically, for classroom tasks, participants performed 2.38 points higher in CR2 than in CR1. For Zoom tasks, participants were more intelligible by .318 points in Z2 compared to Z1 and .804 points more intelligible in Z3 than Z2. The pattern for VR tasks was a bit different, with participants being 1.48 points less intelligible in VR2 compared to VR1, *but* .573 points more intelligible in VR3 compared to VR2.

Finally, contrary to what was found with comprehensible, ANX+ participants were 2.36 and 1.81 points more intelligible than their ANX± peers and ANX- (small effect) peers respectively. This is again surprising, as the preliminary study found ANX- participants to be significantly more intelligible than those that were ANX+ (large effect).

Fluency

Participants' *fluency* scores for each task are shown in Figure 28. Participants' scores ranged from 10.67 to 43.33 words per 20-second speech sample, with a higher word count indicating better fluency.



Key: CR1 = classroom task 1; CR2 = classroom task 2; VR1 = virtual reality task 1; VR2 = virtual reality task 2; VR3 = virtual reality task 3; Z1 = Zoom task 1; Z2 = Zoom task 2; Z3 = Zoom task 3; n/a = participant absent from class; blank = participant did not have option to complete task in that environment that semester
Figure 28: Fluency scores across all six tasks

The means, SDs, and confidence intervals (CIs) for participants' fluency scores are presented in Table 18.

Task	***Mean***	***SD***	***CI** (Low.-Upp)*
CR1	22.0	7.39	18.8 - 25.2
CR2	25.5	8.86	21.1 - 29.9
VR1	23.5	6.62	21.2 - 25.9
VR2	26.6	7.96	23.6 - 29.5
VR3	26.9	7.66	22.0 - 31.7
Z1	22.2	7.45	19.7 - 24.7
Z2	25.0	6.31	22.7 - 27.4
Z3	26.5	5.48	22.8 - 30.2
ANX+	21.7	6.02	20.1 - 23.3
ANX±	24.3	6.70	22.1 - 26.5
ANX-	25.9	7.94	24.3 - 27.5

Table 18. Means, SDs, and CIs of fluency scores

Descriptively speaking, participants as a whole were most fluent during the VR3 task (*M* = 26.9, *SD* = 7.66), followed by the VR2 (*M* = 26.6, *SD* = 7.96), Z3 (*M* = 26.5, *SD* = 5.48), CR2 (*M* = 25.5, *SD* = 8.86), Z2 (*M* = 25.0, *SD* = 6.31), VR1 (*M* = 23.5, *SD* = 8.86), Z1 (*M* = 22.2, *SD* = 7.45), and CR1 (*M* = 22.0, SD = 7.39) tasks. This time, ANX- participants were the most fluent (*M* = 25.9, *SD* = 7.94), followed by their ANX± (*M* = 24.3, *SD* = 6.70) and ANX+ peers (*M* = 21.7, *SD* = 6.02).

A linear model including participant as a random factor and anxiety group (i.e., ANX-, ANX+, and ANX±) as a fixed factor was conducted to examine the impact of environment on fluency scores. The model output, pairwise comparisons, and effect sizes (Cohen's *d*) and confidence intervals are reported in Table 19.

Linear Model Output						***Pairwise Comparisons, Cohens d, & CIs***						
Fixed Effect	**Est.**	**SE**	**DF**	**t-value**	**p-value**	***Pair. Comp.***	**Est.**	**p-value**	**Coh. *d***	**CIs**	
										Low.	**Upp.**
Inter. *(CR1)*	23.953	1.629	62.414	14.709	<.001*	*CR1 / VR1*	-1.687	.836	.216	-5.281	1.908
CR2	3.379	1.346	149.392	2.511	.013*	*CR1 / Z1*	.201	1.000	.027	-3.378	3.779
VR1	1.687	1.169	149.923	1.443	.151	*CR2 / VR2*	-.766	.999	.132	-4.764	3.233
VR2	4.145	1.204	150.659	3.443	<.001*	*CR2 / Z2*	-2.823	.288	-.068	-3.519	4.631
VR3	3.491	1.676	156.554	2.083	.039*	*VR1 / Z1*	1.888	.593	.184	-1.264	5.040
Z1	-.201	1.163	151.017	-.173	.863	*VR2 / Z2*	1.321	.935	.223	-2.105	4.747
Z2	2.823	1.215	151.314	2.325	.021*	*VR3 / Z3*	-.006	1.000	-.060	-5.479	5.466
Z3	3.498	1.723	155.485	2.030	.044*	*CR1 / CR2*	-3.379	.199	.434	-7.517	.759
ANX+	-4.251	2.304	34.978	-1.845	.074	*VR1 / VR2*	-2.458	.315	.425	-5.782	.866
ANX±	-2.909	2.582	35.951	-1.126	.267	*VR2 / VR3*	.653	.999	.038	-4.078	5.384
						Z1 / Z2	-3.024	.085	.402	-6.259	.211
						Z2 / Z3	-.674	.999	.246	-5.501	4.152
						ANX- / ANX+	4.250	.170	-.575 (S)	-1.39	9.89
						ANX- / ANX±	2.910	.504	-.210	-3.40	9.22
						ANX+ / ANX±	-1.340	.885	-.413 (S)	-8.29	5.61

Model = lmerTest:: lmer(fluency~environment + anxietygroup + (1|participant), data = data)
Effect Size: S = small effect size; M = medium effect size; L = large effect size
Table 19. Model output for environment and anxiety on fluency with pairwise comparisons and effect sizes

When comparing how fluency changed across the three environments, participants produced on average 1.69 and 1.88 more words in the 20-second sample in the VR1 task compared to the CR1 task and Z1 tasks respectively. They also produced on average .766 and 1.321 more words in the VR2 task compared to the comparable CR2 and Z2 tasks. Finally, participants produced .006 more words in the VR3 task compared to the Z3 task. However, no significant differences or effect sizes emerged.

When comparing how fluency evolved over the course of the semester, participants were found to slightly improve in each environment. Specifically, for classroom tasks, participants produced 3.379 more words on average in the CR2 task compared to the CR1 task. For Zoom tasks, participants were more fluent by 3.024 words in Z2 compared to Z1 and by .674 words in Z3 compared to Z2. Finally, for VR tasks, participants produced on average 2.458 more words in the VR2 task compared to VR1 and .653 more words in VR3 compared to VR2. However, again no significant differences or effect sizes emerged.

Finally, both ANX- and ANX± participants were found to be more fluent by 4.250 words (small effect) and 1.340 words (small effect) respectively than their ANX+ peers.

Relationship Between Comprehensibility, Intelligibility, and Fluency

RQ3 also aimed to determine whether or not participants' levels of comprehensibility, intelligibility, and fluency were related. The Pearson's correlation used to test the relationship between comprehensibility and intelligibility yielded a moderate positive correlation between the two, $r(191) = .547$, $p < .001$, indicating that intelligibility was higher when participants were more comprehensible (Figure 29).

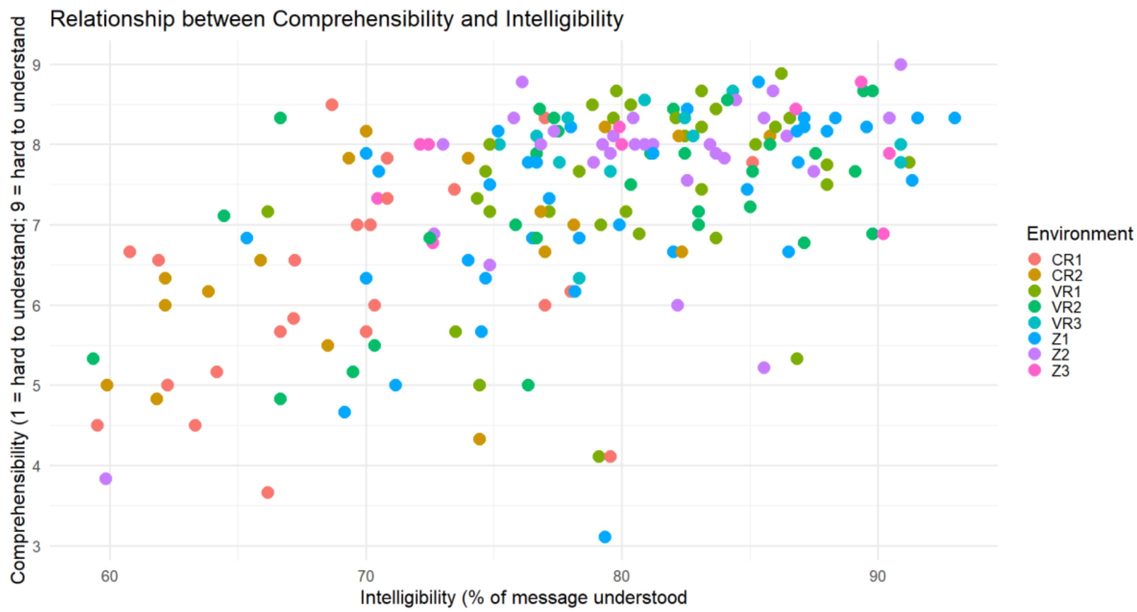


Figure 29. Relationship between comprehensibility and intelligibility

A weak positive correlation was found between participants' comprehensibility and fluency scores, $r(191)$, = .300, p <.001, indicating that comprehensibility scores were higher when participants were more fluent (Figure 30).

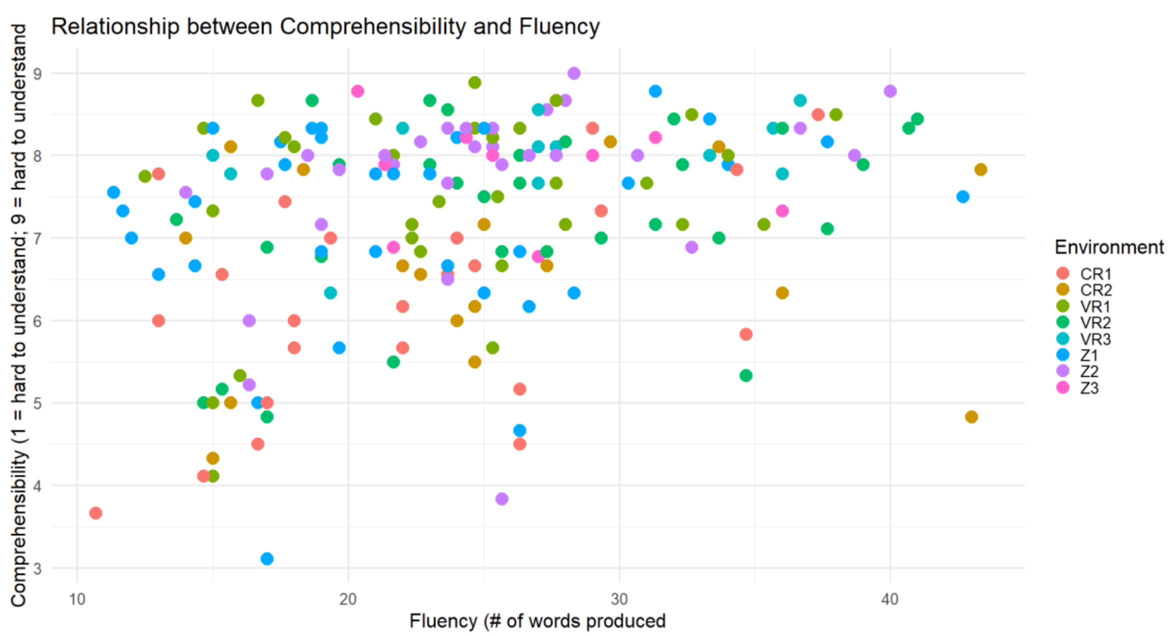


Figure 30. Relationship between comprehensibility and fluency

Finally, a weak negative correlation was found between intelligibility and fluency scores, $r(191) = -.249$, $p < .001$, indicating that as fluency increased, intelligibility decreased (Figure 31).

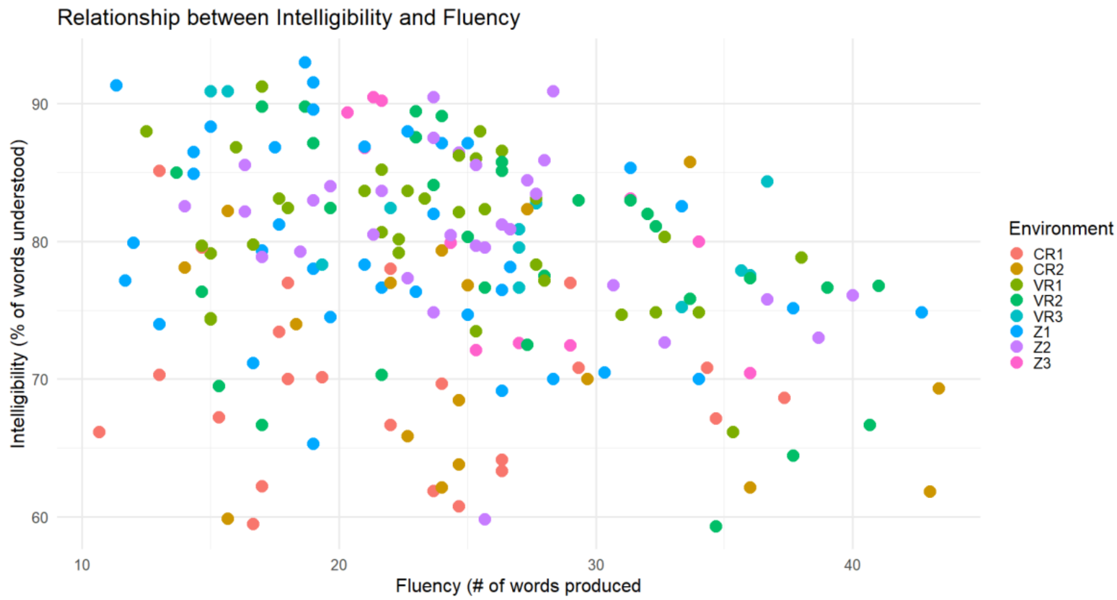


Figure 31. Relationship between intelligibility and fluency

RQ4: Focus Groups' Unfolding Interactions

RQ4 aimed to document how two focus groups' -- one primarily made up of ANX+ participants and one primarily of ANX- participants -- group interactions unfolded across the three learning environments. To recall, using the Interaction Analysis Model (IAM) (Hull & Saxon, 2009), the two groups' discourse was classified into different levels of interaction ranging from 1 (least complex) to 7 (most complex). Then, the findings of the IAM and participants' heart rate data were synchronized and mapped out on a timescale to see how the groups' interactions and heart rates evolved throughout each twenty-minute activity. Finally, participants' heart rate data, the findings of the IAM, and the transcribed and video-recorded conversations were merged to document how and why heart rate fluctuated in response to the unfolding interactions. Please find more details for the methods in Chapter Three: Methodology on pages 85-87.

The findings for Focus Group 1 will first be presented, followed by Focus Group 2. First, the descriptive data of how many times each participant spoke at each IAM level during each task will be given. Then, for each of the 6 activities, vignettes will be presented that first provide a brief overview of what transpired during the entire task and then highlight key moments where participants' heart rate fluctuated (or did not when expected) in response to the unfolding interaction.

Focus Group 1

Focus group 1 was made up of three participants: Samantha (ANX+), Jessica (ANX+), and Nick (ANX-). In order to provide a better overview of these three participants, their personal background information is presented in Table 20.

Participant	***Gender***	***Age***	***Onset Age of Learning***	***Other Languages***	***Substantial Immersion***
Jessica	Female	19	12	Chinese	Yes
Samantha	Female	19	14	Spanish / Korean	No
Nick	Male	19	14	German	No

Table 20. Focus group 1 background information

Jessica (ANX+) was a 19-year-old female student who started learning French at the age of 12. She had substantial prior immersion experience and also knowledge of another language, Chinese. Samantha (ANX+) was also a 19-year-old female student who started learning French at the age of 14. She also had knowledge of other languages – Spanish and Korean – but had no prior substantial immersion experience. Lastly, Nick (ANX-) was a 19-year-old male student who also started learning French at the age of 14. He had knowledge of German but no prior substantial immersion experience.

The results of this group's comprehensibility, intelligibility, and fluency scores, IAM analyses, self-reported anxiety data, and HR data are presented in Table 21.

	Jessica (ANX+)						**Samantha (ANX+)**						**Nick (ANX-)**					
IAM	**VR1**	**CR1**	**Z1**	**VR2**	**CR2**	**Z2**	**VR1**	**CR1**	**Z1**	**VR2**	**CR2**	**Z2**	**VR1**	**CR1**	**Z1**	**VR2**	**CR2**	**Z2**
Level 1: *Direct Instruction to the Group*	1	8	4	10	3	5	6	--	6		5	3	15	14		21	5	
Level 2: *Sharing new Information*	22	16	20	42	30	17	14	7	14		34	15	25	10		30	14	
Level 3: *Situated Definition*	32	12	28	25	14	25	15	12	21		17	12	32	13		21	12	
Level 4: *Intersubjectivity*	16	7	10	10	6	15	13	6	8		4	15	21	5		23	3	
Level 5: *Negotiation/ co-construction*	6	9	3	4	2	3	4	2	5		1	4	2	2		2	--	
Level 6: *Testing Constructions*	2	--	--	1	--	--	--	4	--		--	3	--	--		--	--	
Level 7: *Reporting New Knowledge*	2	--	--	--	--	1	--	--	--		--	--	1	--		1	--	
Total Turns	**81**	**52**	**65**	**92**	**55**	**66**	**52**	**31**	**54**		**61**	**52**	**96**	**44**		**98**	**34**	
Self-Reported Anxiety	22	28	16	**14**	19	16	**18**	24	26		26	24	**11**	22		18	27	
Comprehensibility	8	6.56	8.22	**8.67**	6.56	8.11	**8.67**	6.67	7.78		8.11	8.33	**8.11**	6.56		7.89	5	
Intelligibility	85.2	61.9	78	**89.8**	65.9	79.7	79.8	60.8	76.3		**85.8**	75.8	82.4	67.2		**87.6**	59.9	
Fluency	21.7	23.7	19	18.7	22.7	**25.3**	16.7	24.7	23		33.7	**36.7**	18	15.3		**23**	15.7	
Baseline HR (bpm)	--	80.8	79.9	80.3	99.1	86.8	--	89.9	85.8		--	--	89.8	88.9		82.7	85.7	
Mean HR (bpm)	--	90.3	75.1	76.0	88.2	76.8	--	81.4	79.3		--	--	81.2	87.4		85.9	84.6	
SD HR (bpm)	--	5.3	4.1	4.0	4.8	4.8	--	4.7	5.7		--	--	4.9	4.9		5.9	4.6	

Key: VR1: virtual reality task 1; CR1: classroom task 1; Z1: zoom task 1; VR2: virtual reality task 2; CR2: classroom task 2; Z2: zoom task 2; gray shade: absent for task.

Table 21. Interaction Analysis Model (Hull & Saxon, 2009) focus group 1

Concerning Jessica (ANX+), the number of times she contributed to the group's conversation was the highest in VR (VR2 = 92; VR1 = 81), followed by Zoom (Z2 = 66; Zoom1 = 65) and then the classroom (CR2 = 55; CR1 = 52). She also talked more within each environment over time. Interestingly, the number of times that Jessica contributed to a conversation did not seem to be necessarily tied to her self-reported anxiety. Indeed, although Jessica had the lowest self-reported anxiety and talked the most during the VR2 task, she had relatively high anxiety during the VR1 task, yet contributed greatly to the group's discussion. In terms of the level of her discourse, Jessica (ANX+) reached high, complex levels (i.e., levels 6 and 7) primarily during the VR1 task, but also during VR2 and Z2.

Jessica's mean HR was highest during the CR1 task (90.3 bpm), followed by the CR2 task (88.2 bpm), the Z2 task (76.8 bpm), the VR2 task (76.0) and lastly the Z1 task (75.1). When comparing mean HR to baseline, Jessica experienced an *increase* in HR from her baseline during the CR1 task (9.5 bpm), and a *decrease* from her baseline for the Z1 (4.8 bpm), VR2 (4.3 bpm), CR2 (10.9 bpm), and Z2 (10 bpm) tasks.

Regarding Samantha (ANX+), the number of times she spoke was highest in the CR2 task (61), followed by Z1 (54), Z2 (52), VR1 (52) and CR1 (31). Unlike Jessica (ANX+), Samantha (ANX+) did not necessarily talk more in each environment over time. Moreover, Samantha (ANX+) contributed to the conversation the most when she self-reported higher anxiety (i.e., Z1 and CR2 tasks), which is the opposite of what we would expect to observe. She also reached higher, complex levels (i.e., level 6) of discourse during the CR1 and Z2 tasks. Samantha's mean HR was highest during the CR1 task (81.4 bpm) followed by the Z1 task (79.3 bpm). However, in both instances, her HR decreased from her baseline (CR1: 8.5 bpm, Z1: 6 bpm).

For Nick (ANX-), the number of times he contributed to the group's conversation was highest in VR2 (98) and VR1 (96), followed by CR1 (44) and CR2 (34). This finding mirrors Nick's (ANX-) self-reported anxiety, with him being the least anxious during the VR1 and VR2 tasks than in the CR1 and CR2 tasks. Finally, Nick (ANX-) reached his highest levels of discourse (i.e., level 7), during the VR1 and VR2 tasks.

Nick's mean HR was highest during the CR1 task (87.4 bpm), followed by the VR2 (85.9 bpm), CR2 (84.6 bpm), and VR1 (81.2 bpm) tasks. When comparing mean HR to baseline, Nick had an *increase* in HR from his baseline during the VR2 task (3.2 bpm), and a *decrease* from his baseline for the VR1 (8.6 bpm), CR1 (1.5 bpm), and CR2 (1.1 bpm) tasks.

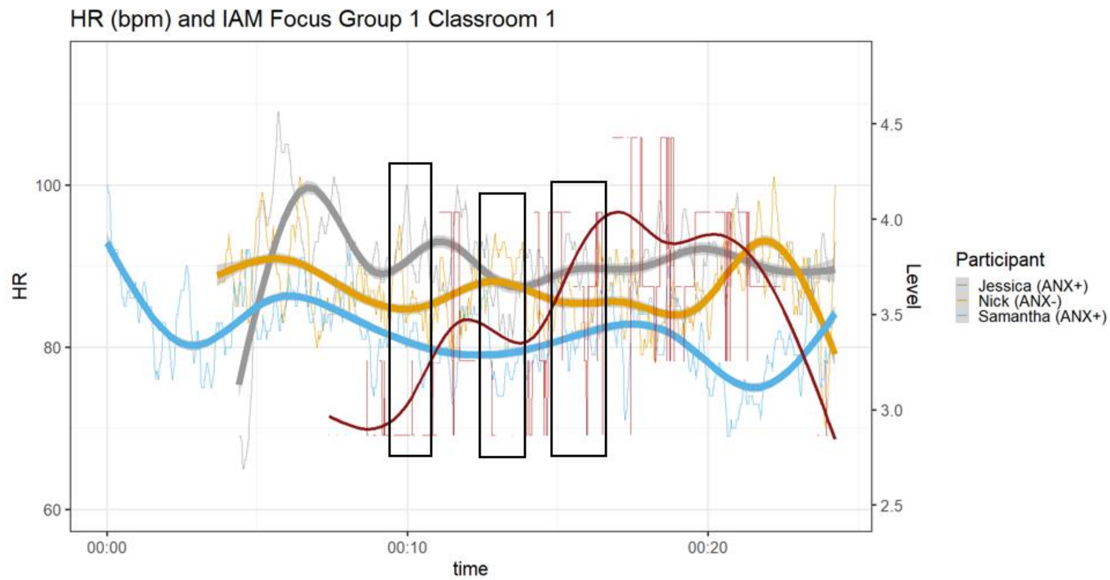
Classroom 1 Task.

Overview.

The first classroom task that Focus Group 1 completed dealt with the subject of technology. For their consensus building activity, Samantha (ANX+), Jessica (ANX+), and Nick (ANX-) had to come up with a technology that could solve an existing problem in society. They were each assigned different hierarchical roles during the task, with Nick (ANX-) being assigned to play a Ph.D. student in engineering at the *Université de Sorbonne*, Samantha (ANX+) a professor of engineering at the same university, and Jessica (ANX+) the CEO of the biggest technology developer in Paris. Over the course of the conversation, the group ultimately decided to create a drone that could help disinfect and clean classrooms for COVID-19.

The unfolding of Samantha (ANX+), Jessica (ANX+), and Nick's (ANX-) coded interaction and each participant's heart rate is shown in Figure 32[7].

[7] It should be noted that participants' heart rates do not always start at the same time as their peers during tasks, as the researcher often had to help students with their heart rate monitors individually. Moreover, there was sometimes a lag between when the heart rate monitors were turned on and when students actually began conversing with each other, since they would sometimes hesitate to get started as a group.



Key: ▭ : key moments; red line: Interaction Analysis Model
Figure 32. FG1s Classroom 1 Interaction Analysis and Heart Rate Levels

For the first classroom activity, the group's conversation was at levels 1-2 for the first few minutes of the activity. It then rose to levels 3-5 at approximately the 12-minute-mark, before returning again to levels 1-2. However, around the 15-minute-mark, the group's interaction rose to levels 4-5 and remained there for approximately 8 minutes. During the last 3 minutes of their conversation, the group's interaction returned to levels 2-3[8].

Key Moments.

Upon triangulating participants' heart rate data, IAM findings, and the video and transcription data of their conversation, three key moments emerged when participants' heart rates appeared to fluctuate in response to their unfolding conversation. The first occurred between the 9-to-11-minute mark. The transcription of the three participants conversation at this point is provided below in French (left side) and English (right side):

[8] It should be noted that these phases happened naturally as participants worked through the task.

Samantha : les bénéfices…je pense uh on peut utiliser la technologie pour des- le - les chirurgies complexes um parce que les chirurgiens peuvent faire des erreurs et uh leurs mains peuvent avoir des *tremors* par exemple uh compliquer les chirurgies et c'est pourquoi les uh les-les robots et choses comme ça par exemple peuvent uh aider à la chirurgie	**Samantha**: *The benefits... I think uh we can use technology for some - the - the complex surgeries um because the surgeons can make mistakes and uh their hands can have some* tremors *for example uh to complicate the surgeries and it's why the uh the-the robots and things like that for example can uh help surgery.*
Jessica: mhm	**Jessica**: *Mhm*
Jessica: un bonne idee	**Jessica**: *A good idea.*
Samantha : un risque est-ce que la technologie peut malfo-malfonc-malfonctionner	**Samantha**: *A risk, is it that the technology can mal-malfunc-malfunction.*
Jessica : ouais	**Jessica**: *yeah*
Jessica: um...*sigh* hm...hm...	**Jessica**: *um... *sigh* hm... hm...*
Nick : Av- avec uh l'utilise de de de la technologue uh etait um c'est poss possible que tout le monde uh devient uh très paresseuse	**Nick**: *Wi-with the uh the uses of-of-of technology uh it was uh it is poss-possible that everyone uh becomes uh very lazy.*
Samantha : mhm	**Samantha**: *mhm*
Jessica : mhm	**Jessica**: *mhm*
Nick : parce que ils - ils ne peuvent pas - ils ne peuvent rien - rien	**Nick**: *because they - they cannot - they can nothing - nothing.*
Jessica : ummm	**Jessica**: *ummmm*
Jessica : je pense que aussi like les - les chirurgiens utilisent like les robots et les machines um je pense que um le - l'etude pour les doctors ou like les medicins maybe - médecins	**Jessica**: *I also think that* like *the-the surgeons use* like *the robots and the machines um I think that um the studies for* doctors *or* like *the doctors* maybe - *doctors.*
Samantha : mhm mhm	**Samantha**: *Mhm, mhm*

Nick : oui je pense	**Nick**: *yes, I think.*
Samantha : medecin?	**Samantha**: *doctor*?
Nick : uh oui	**Nick**: uh *yes*
Jessica : oh *laughter* uh peut augmente pour - pour um apprendre le - la technologie	**Jessica**: *oh* *laughter* *uh can increases for - for um to learn the - technology*

At this moment in the conversation, Samantha's (ANX+) heart rate was actively decreasing. This is not surprising, as she was only speaking at a level-3 and was not experiencing much linguistic breakdown compared to her group members. Moreover, Samantha (ANX+) contributed at the beginning of this portion of the group's conversation, and then took a more passive role while Jessica (ANX+) and Nick (ANX-) voiced their opinions, which could have momentarily lowered her anxiety. Concerning Nick (ANX-), his heart rate rose slightly throughout this exchange. Although Nick (ANX-) was only speaking at a level-2 at this time, he had several linguistic breakdowns that could have contributed to his anxiety, notably when trying to explain that technology could make people lazy since they would not have to do anything themselves anymore. For Jessica (ANX+), she was the one participant who attempted to co-construct meaning with her peers by contributing a level-5 comment to the conversation. At this point, this was the highest level of discourse that had been reached. When examining the graph of Jessica's (ANX+) heart rate, we can see that it rose over the course of her expressing this more complex thought and as she experienced linguistic breakdown when trying to find the word for "doctor" (*médecin*) in French.

The second moment in the conversation where participants' heart rates fluctuated in response to their group interactions was between the 13-to-14-minute mark. The transcription of the three participants conversation at this time is provided below:

Samantha : oui je pense que oui - parce que je me - je me souviens que j'ai un- j'avais regardé un show au télévision où un chirurgien uh il était en pratique pour beaucoup des ans et uh "on top of it" like um il um aussi um voudrait apprendre à utiliser la technologie et faire des chirurgies avec la technologie donc	**Samantha**: *yes, I think so yes. Because I-I remember that I have a - I had watched a show on television where a surgeon uh he was practicing for a lot of years and uh* on top of it like *um he um also um would want to learn to use technology and do surgeries with technology so.*
Jessica: mhm	**Jessica**: *mhm*
Jessica: mm *clears throat* uhh ok ummm	**Jessica**: *mm* *clears throat* *uh ok ummmm*
Nick : c'est *clears throat *c'est-c'est difficile uh c'est difficile pour uh t'entendre uh avec les masques - its - je ne peux pas decider uh si je deteste uh en classe ou en ligne le le plus	**Nick**: *It's* *clears throat* *It's- it's difficult uh it's difficult to uh to hear you uh with the masks.* Its - *I cannot decide uh if I hate uh in class or online the-the most.*
Samantha : hm?	**Samantha:** *hm?*
Nick : I can't decide if I don't like it - if I like it in class or online less because of the audio	**Nick:** I can't decide if I don't like it- if I like it in class or online less because of the audio
Samantha: mhm	**Samantha**: *mhm*
Jessica: hmm hmmmmm	**Jessica**: *hmm hmmmmm*
Nick: alors um uh est-ce que uh vous - vous voulez uh ecri - ecrivez on un-un feuille de papier pas de toi feuille	**Nick**: *so, um uh do uh you-you want uh wri-write* on *a-a sheet of paper not you paper*
Samantha : mhm	**Samantha:** *mhm*
Nick : um écrire tout - écrivez tous - tous les idées uh on sa papier	**Nick:** *um to write everything - write everything - all the ideas uh* on *her paper.*
Jessica: umm I don't think you have to	**Jessica**: *umm I don't think you have to*

At this point, Jessica's (ANX+) heart rate had gone down after the earlier peak when she was expressing her level-5 thought. This is not surprisingly, as the group's conversation had briefly returned to levels 2-3, and she was also not actively contributing to the conversation. However, Nick (ANX-) and Samantha (ANX+) were conversing, and their heart rates were rising at this moment. For Samantha (ANX+), although the group's conversation was only at a level-3, she was experiencing a linguistic breakdown where she could not find the words to say "on top of it" in French. Immediately after being unable to find this expression, her speech was characterized by several hesitations and "ums" that could be reflective of her anxiety at this time. For Nick (ANX-), it seems that two things were contributing to his anxiety: (1) COVID-19 and (2) the conversation itself. At this point in the conversation, Nick (ANX-) abruptly switched topics to tell his classmates that he did not know if he liked having classes in person because of all the COVID-19 protocols, explaining that the masks were making it hard for him to understand his classmates. Nick's (ANX-) heart rate immediately started rising when he was explaining this, which is not surprising given that Nick (ANX-) was a participant who frequently mentioned that the COVID-19 pandemic was causing him stress. However, once the conversation about the task resumed, Nick (ANX-) struggled to ask his classmates if they wanted to write their responses down on a piece of paper and we can see that his heart rate continued to rise.

The third moment in the conversation where participants' heart rates fluctuated in response to their group interactions was right around the 15-to-17-minute mark. The transcription of the group's conversation at this point is provided below:

Jessica : les um les drones va en um en um en un endroit pour les produits de sanitation ?	**Jessica**: *the um the drones goes in um in um in a place for the sanitation products?*
Nick : uh	**Nick**: *uh*
Jessica : est-ce que	**Jessica**: *is it*
Nick : like	**Nick**: like

Jessica : quel-quel message est-ce que tu penses nous pouvons utilise pour le - les drones ?
Nick : uhh
Jessica : *laughter*
Nick : um un drone pour chaque uh - quel est le mot pour 'building'?
Jessica : bâtiment
Nick : bâtiment uh un drone pour chaque bâtiment uh et un drone uh le drone vole sur le bâtiment et saniter tous
Jessica : like sterile le batiment?
Nick : what? *laughter*
Jessica : le - le drone san - nettoie - like sterile le bâtiments?
Nick : uh
Jessica : je ne - je ne sais pas *laughter*
Jessica : *laughter* jusqu'a le drone est utilisé. Okay. *laughter* I just want -
Nick : je suis triste *laughter*
Jessica : *laughter* oh my god
Nick : *laughter*
Jessica : uh Samantha, tu crois que ça marche ?
Nick : umm
Samantha : je pense que le drone peut être trop précise peut-être le-le drone peut être uh utiliser la technologie pour voir si uh si les uh les organismes sont uh sur les uh

Jessica: *what-what message do you think we can uses for the-the drones?*
Nick: *uhhh*
Jessica: *laughter*
Nick: *um a drone for each - uh what is the word for* building
Jessica: *building*
Nick: *building. uh a drone for each building uh and a drone uh the drone flys on the building and* sanitizes *everything*
Jessica: like sterile *the building?*
Nick: what? *laughter*
Jessica: *the - the drone* - san - *cleans* like sterile *the buildings*?
Nick: *uh*
Jessica: *I don't - I don't know.* *laughter*
Jessica: *laughter* *until the drone is used.* Okay. *laughter* I just want-
Nick: *I am sad* *laughter*
Jessica: *laughter* oh my god
Nick: *laughter*
Jessica: *uh Samantha, you think that this works?*
Nick: *ummm*
Samantha: *I think that the drone can be very precise maybe the-the drone can be uh use the technology to see if uh if the uh the organisms are uh on the uh*

Samantha : uh uh ils-ils uh ils peuvent uh-ils peuvent utiliser uh les drones - les drones peut uh voler sur les uh les surfaces et peut avoir uh des technologies pour regarder s'ils prevent uh les - les uh bactéries sont uh morts	**Samantha**: *uh uh - they-they uh they can uh they can use uh the drones - the drones cans uh fly on the uh the surfaces and can have uh some technology to look for - if they* prevent *uh the-the bacteria are uh dead*
Nick : *referencing his face shield* there's like this scuff on mine	**Nick**: *referencing his face shield* there's like this scuff on mine.
Jessica : I know	**Jessica**: I know
Jessica : c'est	**Jessica**: *It's*
Samantha : pour utiliser la technologie biologique	**Samantha**: *to use bio-technology*
Jessica : jus-juste pour like les universités ou pour like -	**Jessica**: *jus-just for* like *universities or for* like
Samantha : maintenant commençons par U of I et après si *inaudible*	**Samantha**: *let's start now by* U of I *and after if* *inaudible*
Jessica : ummm qu'est-ce que c'est la différence entre ça et comme like une um lumière bleue or like les like the thingy that you just go like *hand motion*	**Jessica**: *ummm what is it the difference between this and like* like *a um blue light* or like *the* like the thingy that you just go *hand motion*
Nick : *laughter*	**Nick**: *laughter*
Samantha : like disinfecting them? or like	**Samantha**: like disinfecting them? or like
Jessica : yeah - like like c'est un- un lumière qui- qui- qui trouve like les les les choses sur un surface	**Jessica**: yeah - like like *it's an light that-that-that finds* like *the-the-the things on a surface*
Samantha : um parce que on peut programmer le drone pour voler sur tous les um tous les um corners et aussi on peut utiliser le drone um dans le extérieur pour désinfecter les choses comme um comme les uh comme les railings and stuff et um oui	**Samantha**: *um because we can program the drone to fly on all the um all the um* corners *and also we can use the drone um in the exterior for disinfect things like um like the um like the* railings and stuff *and um yes because I don't think that there is um*

parce que je ne pense pas que il y a um suffisamment de staff pour nettoyer tout-tout le campus.	*because I don't think that there is um sufficiently of staff to clean all-all the campus.*

Throughout this segment of the conversation, Nick (ANX-) was the only participant whose heart rate was decreasing. However, it should be noted that Nick (ANX-) only contributed to the conversation at the beginning, and then did not partake in Samantha (ANX+) and Julia's (ANX+) exchange, aside from making a comment in English about his face shield. However, both Samantha (ANX+) and Jessica's (ANX+) heart rates were rising. Interestingly, this was the first point in the conversation where participants brought their conversation up to levels 4 & 5, as they were negotiating with each other. Indeed, there was initially disagreement between participants, with Jessica (ANX+) challenging Samantha (ANX+) and Nick's (ANX-) idea about creating a drone that could fly around and disinfect surfaces, saying that she didn't understand how it was any different than already existing blue light technology. Samantha (ANX+) responded to her, explaining that a drone could be more precise than human janitors, and therefore benefit the COVID-19 pandemic. Moreover, when trying to argue their viewpoints, Samantha (ANX+) and Jessica (ANX+) both experienced potentially anxiety-inducing linguistic breakdowns that were characterized by frequent re-starts and use of English.

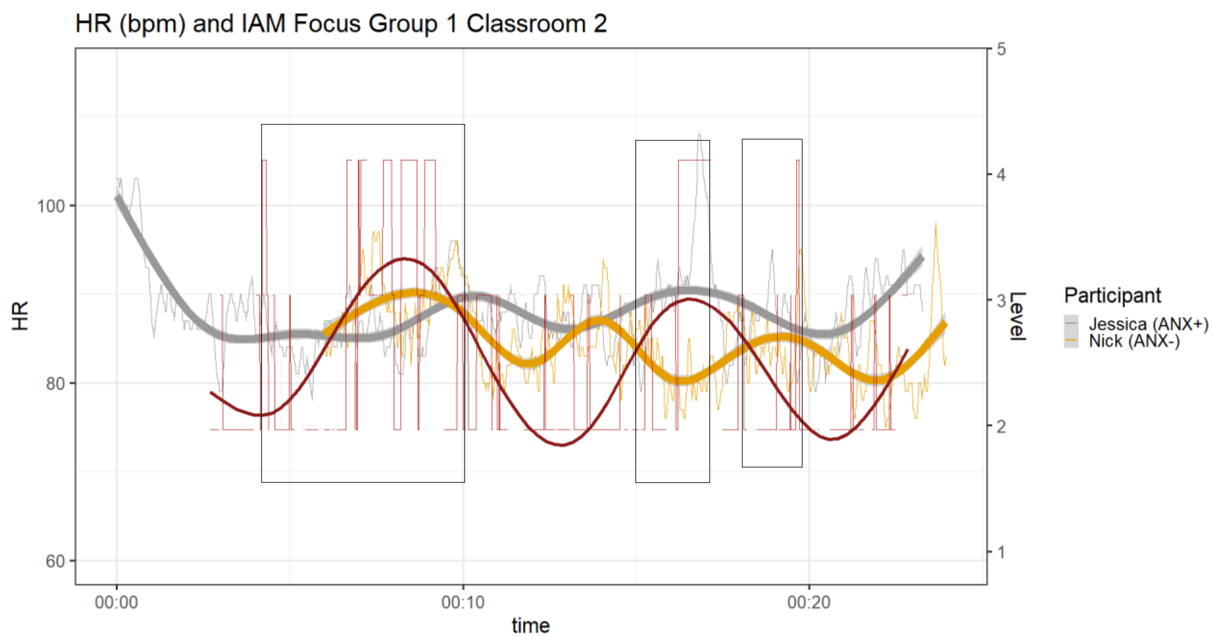
Classroom 2 Task.

Overview.

The second classroom task that Focus Group 1 completed was about the 2024 Paris Olympics. For their consensus building activity, Samantha (ANX+), Jessica (ANX+), and Nick (ANX-) had to come up with a plan for organizing the Olympic games in Paris in 2024. They were each asked to play different hierarchical roles during the task, with Nick (ANX-) being given the president of the planning committee, Samantha (ANX+) the vice-president, and Jessica

(ANX+) the treasurer. Over the course of the conversation, the group ultimately came up with a plan for the 2024 Olympics while considering sanitary and financial constraints.

The unfolding of Samantha (ANX+), Jessica (ANX+), and Nick's (ANX-) coded interaction and heart rate data is shown in Figure 33[9].



Key: ▭ : key moments; red line: Interaction Analysis Model
Figure 33. FG1s Classroom 2 Interaction Analysis Levels

For the second classroom activity, the group's conversation was at levels 1-3 for roughly the first two-to-seven minutes of the activity. It then rose briefly to levels 4-5 around the eight-minute mark, before returning again to levels 1-2. For the remainder of the activity, the group fluctuated between levels 1, 2, and 3. During the last few minutes of their conversation, the groups interaction finally hit a level 4.

[9]Samantha's heart rate was not collected during this activity since she did not bring her heart rate monitor to class.

Key Moments.

Upon triangulating participants' heart rate, IAM findings, and video and transcription data of their conversation, three key moments emerged when participants' heart rates fluctuated in response to their unfolding conversation.

The first moment occurred during the first few minutes of the task, from approximately the 3-to-10-minute mark. The transcription for the group's conversation at that point is given below.

Samantha : oh ou les um - nous pouvons trouver un-un endroit moins cher où les jeux se déroulent um	**Samantha**: *oh or the um we can find a-a less expensive place where the games take place um*
Jessica : mhm	**Jessica**: *mhm*
Jessica : est-ce que les um les cérémonies - les premières cérémonies c'est plus importantes pour JO ?	**Jessica**: *are the um the ceremonies - the first ceremonies is more important for the Olympic games?*
Nick : désolé uh quel- uh - quelle question ?	**Nick**: *sorry uh which-uh-which question?*
Samantha : uh deux	**Samantha**: *uh two*
Jessica : deux - like le deuxième partie	**Jessica**: *two* like *the second part*
Nick : deux ?	**Nick**: *two*?
Samantha : uh huh la deuxième	**Samantha**: *uh huh the second*
Jessica : et aussi like les-les handing off the feu, c'est-c'est important ou pas ?	**Jessica**: *and also* like *the-the* handing off the *torch, it's-it's important or not*?
Samantha : oh le feu!	**Samantha**: *oh, the torch!*
Samantha : mhm	**Samantha**: *mhm*
Nick : *laughter*	**Nick**: *laughter*
Samantha : je pense que pour la première partie, nous pouvons avoir un budget plus cher et pour le reste des jeux c'est peut-être moins cher	**Samantha**: *I think that for the first part, we can have a more expensive budget and for the rest of the games, it's perhaps less expensive.*

Jessica : so, le première plus chère et le majorité moins chère ?	**Jessica**: so*, the first more expensive and the majority less expensive?*
Samantha : mhm	**Samantha**: *mhm*
Samantha : oui parce que comme tu as dit, je pense que le feu est important pour la cérémonie d'ouvert – ouverture – the opening cérémonie	**Samantha**: *yes because as you said, I think that the torch is important for the ceremony the open - the opening* - the opening *ceremony*.
Jessica : exactement nous sommes d'accord. uh uhhh ok Nick, est-ce que *laughter* comment pourriez-vous réduire le cout de l'événement ?	**Jessica**: *Exactly, we agree. uh uhh ok Nick, is - *laughter* how could you reduce the cost of the event?*
Nick : uh uh uh quand nous uh uh pouvons uh the word for build? to build?	**Nick**: *uh uh uh when we uh uh can uh* the word or build? to build?
Samantha : build? oh construire? constru-	**Samantha**: build? *oh to build? buil-*
Nick : con-contruire? um constr-	**Nick**: *to bui-build? um to buil-*
Jessica : construire	**Jessica**: *to build*
Samantha : oh co-con-construire ou bâtir.	**Samantha**: *oh to bu-buil-build or construct*
Nick : uh quand nous uh construire - construirions uh les - l'effort pour les, uh nous ne pens- nous ne pensons pas sur les spectateurs alors les-les spectateurs uh peut peut-être uh plus uh petits	**Nick**: *uh when we uh to build - would build uh the - the effort for the - uh we don't thin- we don't think on the spectators so the - the spectators uh can - perhaps uh more uh small.*
Samantha : peut quoi ?	**Samantha**: *can what?*
Nick : je suis désolé	**Nick**: *I am sorry.*
Samantha : non, non you're good	**Samantha**: *no, no* you're good
Nick : okay	**Nick**: okay
Samantha : um les spectateurs quoi ?	**Samantha**: *um the spectators what?*
Nick : uh quoi	**Nick**: *uh what?*
Samantha : t'as dit que les spectateurs quoi ?	**Samantha**: *you said that the spectators what?*
Nick : uhh	**Nick**: *uhh*

Jessica: the people in training?	**Jessica** : the people in training?
Nick : oui uh sans les spectateurs, uh le-le stade uh *sigh* le stade uh peut être uh plus petit alors uh moins de mater-matériels	**Nick**: *yeah uh without the spectators, uh the-the stadium uh *sigh* the stadium uh can be uh smaller so uh less mat-materials.*

At this point in the conversation, Jessica's (ANX+) heart rate remained relatively stable from the 3-to-8-minute mark while her and Samantha (ANX+) were discussing at levels 2-3. However, as Jessica (ANX+) started advancing the conversation to a level 4 by asking Samantha (ANX+) questions about the importance of the opening ceremony and the passing of the Olympic torch, her heart rate increased simultaneously (~8-10-minute mark). For Nick (ANX-), his heart rate also increased during this time (~6-9-minute mark), but it seemed to be due to two reasons. The first being that Nick (ANX-) arrived late to class that day and had to interrupt his classmates to ask what question they were working on. Upon doing so, his heart rate immediately started to increase. Shortly after, Nick (ANX-) tried to contribute to the conversation after Jessica (ANX+) asked him how he thought they could reduce the cost of the event. When trying to respond, Nick (ANX-) experienced linguistic breakdown prompted by his inability to find the word for "to build" (*construire*) in French. He even apologized to Jessica (ANX+) and Samantha (ANX+) for not being able to clearly express his ideas during this time. His heart rate continued to rise, suggesting that this breakdown contributed to his anxiety.

We see similar instances for both Nick (ANX-) and Jessica (ANX+) between the 15 and 17-minute mark. The transcription for this portion of the conversation is given below:

Jessica : au-aussi parce que like uh le - augmente like le le le oh my gosh le prix pour les pub-publicités parce que beaucoup de personnes voir les JO sur la télé mais donc il y a peut-être plus les	**Jessica**: *al-also because* like *uh the increase* like *the the the* oh my gosh *the price for the adv-advertisements because a lot of people to watch the Olympic games at the tv but so there are perhaps more*
Nick : uh what?	**Nick**: uh what?

Jessica : beaucoup des uh	**Jessica**: *a lot of uh*
Samantha : like ads?	**Samantha**: like ads?
Jessica : oui oui beaucoup des like adds et	**Jessica**: *yeah yeah a lot of* like adds *and*
Nick : commercials? wait no uhh	**Nick**: commercials? wait no uhh
Jessica : oui et les uh, non moins ça, oh my gosh, pendant le	**Jessica**: *yes and the uh no less that*, oh my gosh *during the*
Nathan : advertissements? *laughter*	**Nick**: advertisements? *laughter*
Jessica : oui oui like les what do you call like le uh paid promotions pas paid promotions but like	**Jessica**: *yes*, *yes*. Like *the* what do you call like *the* uh paid promotions, *not* paid promotions but like
Samantha : ohh	**Samantha**: ohh
Jessica : PG ? et like PG?	**Jessica**: PG? *et* like PG?
Nick : hmm uhh	**Nick**: *hmm uhh*
Jessica : like les-les -like les promotions?	**Jessica**: like *the-the* like *the* promotions?
Samantha : like endorsements? err-on peut faire like	**Samantha**: like endorsements? err- *we can do* like
Jessica : yeah yeah yeah yeah plus de endorsements.	**Jessica**: yeah yeah yeah yeah *plus de* endorsements
Samantha : de célébrité ou de président ou ?	**Samantha**: from celebrities or president or?
Jessica : oh like les comme les les les les compagnies et les like PNG et comme like Adidas or whatever like plus des oh my gosh	**Jessica**: oh like *the like the-the-the-the companies and the* - like PNG *et like* like Adidas or whatever *like more of* oh my gosh
Samantha : hm, okay.	**Samantha**: hm, okay.
Samantha : ohh wait. okay. I get what you're saying.	**Samantha**: ohh wait. okay. I get what you're saying

For Nick (ANX-), his heart rate noticeably decreased during this time, which is not surprising considering he did not contribute to the group's conversation aside from a few 1-to-2-word comments that were mostly in English. However, we see a reverse pattern for Jessica (ANX+), who tried to express an idea that was linguistically challenging for her since she could not find the word for “endorsements” (*publicités*) in French. At this point, Jessica’s (ANX+) heart rate started rising and her speech was characterized by her repeatedly saying “oh my gosh” and “like” as she struggled to find the words to express herself.

The last moment where Jessica (ANX+) and Nick’s (ANX-) heart rates were clearly impacted by their on-going conversation occurred at the end of the task around the 18-to-20-minute mark. The transcription for this portion of the conversation is given below:

Jessica : oui like en sur les jeux de Rio. C'est toujours à Rio ? Je ne sais pas.	**Jessica**: *yes* like *in on the Rio games. It’s still in Rio? I do not know.*
Samantha : um, je ne sais pas	**Samantha**: *um, I do not know.*
Nick : je ne sais pas	**Nick**: *I do not know.*
Samantha : je ne fais pas plus attention à les jeux	**Samantha***: I do not pay attention anymore to the games.*
Nick : vous alle - vous allez regarder tous les-tous les endroits de l'élection	**Nick**: *you going - you are going to watch all the-all the places of the election?*
Jessica : oui	**Jessica**: *yes.*
Jessica : oh *laughter* mon prof a un examen ce matin et...j'ai dit non *laughter*les uh uh je ne sais pas	**Jessica**: *oh *laughter* my professor has an exam this morning and...I said no.* *laughter* *the uh uh I do not know.*
Nick : mm	**Nick**: *mm*
Samantha : oh no *laughter*	**Samantha**: *oh no* *laughter*
Samantha : c'est difficile parce que um hier était les élections et je ne-je ne faisais - je ne pouvais faire attention à mon devoir parce que j'ai j'étais trop-trop-trop occupée	**Samantha**: *it’s difficult because um yesterday was the elections, and I don’t - I don’t - I can’t pay attention to my homework because I was - I was too-too-too busy.*
Jessica : oh no, oh non. moi aussi, moi aussi	**Jessica**: *oh no, oh no. me too, me too.*
Samantha : mhm	**Samantha**: *mhm*

Nick : Si Trump gagnerai - gagnera, je déménagerai avec ma copine à Canada ou au Bordeaux	**Nick**: *If Trump will win-win, I will move with my girlfriend to Canada or to Bordeaux.*
Samantha : mhm	**Samantha**: *mhm*
Jessica : *laughter*	**Jessica**: *laughter*
Samantha : où où?	**Samantha**: *where where?*
Nick : Bordeaux	**Nick**: *Bordeaux*
Jessica : oh, oh	**Jessica**: *oh, oh*
Steffane : ah, oh	**Samantha**: *ah, oh*
Jessica : mais uh fingers crossed mais Wisconsin et Michigan mm	**Jessica**: *but* uh fingers crossed *but Wisconsin and Michigan mm*
Samantha : *laughter* est-ce que vous avez regardé des memes de Spongebob ?	**Samantha**: *laughter* *have you all looked at the Spongebob memes?*
Jessica : non	**Jessica**: *non*
Nick : Avec Wisconsin et Michigan uh - avec - maintenant uh Biden est - Biden doit de 16 plus electors	**Nick**: *With Wisconsin and Michigan, uh with - now uh Biden is - Biden needs 16 more electors.*
Nick : désolé je suis stressé	**Nick**: *sorry, I am stressed*

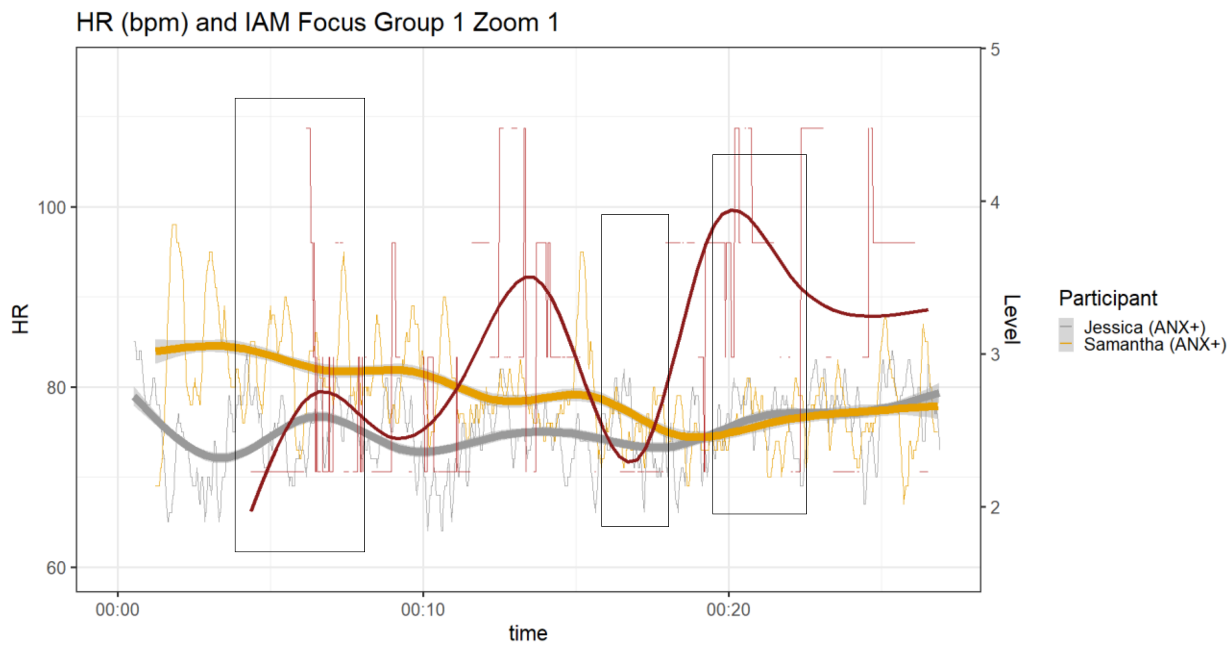
At this point in the conversation, Nick (ANX-) had changed the topic to the 2020 Presidential elections that had occurred the night before and of which the outcome was still being determined. All students appeared stressed about waiting for the results. Yet surprisingly Jessica's (ANX+) heart rate was decreasing at this point in time. Perhaps this is because although the conversation topic was stressful, the group's interaction was still rather simple (i.e., levels 1-3). However, for Nick (ANX-), his heart rate increased during this part of the conversation. This is not surprising given that Nick (ANX-) was particularly stressed regarding the election, with him even explicitly stating "je suis stressé" (*I am stressed*) after discussing the potential outcomes with his group.

Zoom 1 Task.

Overview.

The first *Zoom* task that Focus Group 1 completed centered around the subject of the environment. Nick (ANX-) did not attend class this day, and later expressed that he particularly hated using *Zoom* during the COVID-19 pandemic and that he avoided it when possible. This is important, as this extreme avoidance could severely impact his language learning long-term. However, for their activity, Samantha (ANX+) and Jessica (ANX+) worked together to organize a workshop on sustainability that would teach the local people of Champaign how to be more mindful of the environment. They were each given different hierarchical roles during the task, with Jessica (ANX+) being assigned to play the Director of *The Champaign County Sustainability Network* and Samantha (ANX+) a volunteer of the organization. Over the course of the conversation, Jessica (ANX+) and Samantha (ANX+) ultimately decided that the workshop would focus on reducing pollution and that they would invite speakers from certain companies to come talk to the Champaign locals.

The unfolding of Samantha (ANX+) and Jessica's (ANX+) coded interaction and heart rates is shown in Figure 34.



Key: ▭ : key moments; red line: Interaction Analysis Model
Figure 34. FG1s Zoom 1 Interaction Analysis Levels

Samantha (ANX+) and Jessica's (ANX+) conversation was at levels 1-2 for the first few minutes of the activity. It then rose briefly to levels 3-4 around the 7-minute mark, before returning again to levels 2-3. However, around the 11-minute mark, it increased to a level 4, and eventually briefly to a level 5. It then fluctuated between levels 3-5 for several minutes. Then, around the 15-minute-mark, the group switched topics and their conversation returned to levels 1-2. Following, around the 18-minute mark, the group returned to higher levels of discourse (level 4) and fluctuated between levels 2-5 for the remainder of the activity.

Key Moments.

The first moment where we see that Jessica's (ANX+) heart rate increased and that Samantha's (ANX+) decreased in response to their interaction occurred from approximately the 5-to-8-minute-mark. The transcription for the conversation at this point in time is given below:

Jessica : *laughter*... umm ... *clears throat*...hmmm... hmm... uh I guess premièrement, le l'effet de serre est um est augmenté ou l'effet de serre augmente plus plus uh aujourd'hui et donc uh ça beaucoup des des effets uh des effets mauvaises. Uh donc il y a beaucoup des uhm des uhm mauvaises des effets mauv - mauvaises effets. Okay, il y a beaucoup des effets détruire qui okay oh my gosh sorry this - il y a beaucoup - ok ça cause beaucoup de des détriments dans le environnement avec les habites dans les uhm comme la pollution comme la glacier comme beaucoup de choses, il détruit la planète je pense donc c'est aussi une raison pour uh protéger l'environnement.	**Jessica** : *laughter* *umm…* *clears throat* *hmmm...hmm...uh* I guess *first, the-the greenhouse gas effect is um is increased or the greenhouse gas effect increases more-more uh today and so uh this a lot of-of effects uh of effects bad. Uh so, there is a lot of um of um bad of effects ba-bad effects.* Okay*, there are a lot of effects to destroy which* okay oh my gosh sorry this - *there are a lot - okay this causes a lot of-of detriments in the environment with the habits in the um like pollution, like glaciers, like a lot of things. It destroys the planet I think so it's also a reason for uh to protect the environment.*
Samantha : mhm	**Samantha**: *mhm*
Samantha : So il y a beaucoup des uh des uh des choses mauvais qui détruit l'environnement	**Samantha**: So, *there are a lot of uh of uh of things bad that destroys the environment.*
Jessica : Oui like à cause de l'effet de serre et le réchauffement climatique donc à cause de ça oui	**Jessica**: *Yes* like *because of the greenhouse gas effect and global warming so because of that yes.*
Samantha : l'effet?	**Samantha**: *effect?*
Samantha : wait l'effet de what?	**Samantha**: wait *effect of* what?
Jessica : L'effet de serre	**Jessica**: *the greenhouse gas effect*
Samantha : What is that?	**Samantha**: what is that ?
Jessica : Uhm...uhm.. like the greenhouse gas effect I think? Une	**Jessica**: uhm…uhm...like the green house gas effect I think? *A*
Samantha : Serre?	**Samantha**: *greenhouse gas* ?

Jessica : L'effet de serre je - yeah green house effect. c'est - c'est le green house effect. C'est comme like le le rechauffement climatique

Samantha : How do you spell that?

Jessica : Uhh I think it's just S-E-R-R-E l'eff- like l'effet de serre

Samantha : S-E-R-R

Samantha : *reading what she typed* il y a beaucoup de mauvais choses qui détruit l'environnement comme l'effet de serre

Jessica : Hm..tu as quelques-quelques idées ?

Samantha : Uh...oui, uh...*reading* parler en groupe […] avec 3 raisons pour lesquelles il est absolument nécessaire de protéger l'environnement - parce que l'environnement uh provides beaucoup des ressources naturelles que nous utilisons

Jessica : Mhm. Je

Samantha : How do you say provides?

Jessica : I think it's like fournir like or four-fournissent or four-fournissent

Samantha : Oh !

Jessica : Hm... non c'est, c'est vrai um.

Samantha : Moyen de fourni?

Jessica : Okay trois... Uh... aussi je pense que c'est c'est notre re-responsabilité uhm à protéger l'environnement parce que like nous like le population cause le like le le oh

Jessica: *greenhouse gas effect I* - yeah greenhouse effect. *it's-it's the* greenhouse effect. *It's like* like *gl-global warming.*

Samantha: How do you spell that?

Jessica: Uhh I think it's just S-E-R-R-E *the gre-* like *the greenhouse gas effect.*

Samantha: S-E-R-R

Samantha: *reading what she typed* *there are a lot of bad things that destroys the environment like the greenhouse gas effect.*

Jessica: *Hm..you have any-any ideas?*

Samantha: *Uh…yes, uh…*reading* talk in your group [...] with three reasons for which it is absolutely necessary to protect the environment - because the environment uh* provides *beaucoup of natural resources that we use.*

Jessica: *Mhm. I*

Samantha: How do you say provides?

Jessica: I think its like *to provide* like or *pro-provides* or *pro-provides.*

Samantha: Oh!

Jessica: *Hm...non c'est, c'est vrai um.*

Samantha: *Way of provide ?*

Jessica: Okay *trois...Uh...also I think that it's-it's our re-*responability *um to protect the environment because* like *we* like *the population causes the* like *the the* oh my gosh *cause the destr- cause uh the* my gosh

cause le detr- cause uh l'environnement à nouer donc oh non uh tuer donc oui c'est un peu le responsabilité.	*environment to tie so oh no uh to kill so yes it's a little the responsibility.*
Samantha : hmm	**Samantha**: hmm

Regarding Samantha (ANX+), her heart rate decreased throughout the beginning of this exchange, as she was playing a more passive role in the conversation and either listening to Jessica (ANX+) or responding with clarifying questions about what "greenhouse gas effect" (*l'effet de serre*) meant in French. Conversely, Jessica's (ANX+) heart rate was rising throughout this time, which is not surprising considering her heart rate had been shown to increase when she experienced linguistic breakdown. We can see that Jessica (ANX+) was particularly struggling to express her first thought, characterized by her saying "oh my gosh, sorry this" in English. However, towards the second half of their exchange, we can see that Samantha's (ANX+) heart rate started rising while Jessica's (ANX+) started decreasing. Indeed, at this point in time, Samantha (ANX+) started to more actively participate in the conversation after Jessica (ANX+) prompted her with the question "do you have any ideas?" (*tu as quelques idéés* ?). When trying to respond, Samantha (ANX+) was unable to find the word for "provides" (*fournir*) in French, which could have contributed to an increase in anxiety and heart rate. Contrary to what would be expected though, Jessica's (ANX+) heart rate was lowering during this time, despite the fact that she had significant linguistic breakdown when trying to express how we, as humans, are responsible for protecting the environment since we are the ones who have destroyed it. This is surprising, as these types of breakdowns typically triggered Jessica's (ANX+) anxiety and led to her heart rate rising.

The second point in the conversation where we can see Samantha (ANX+) and Jessica's (ANX+) heart rates responding to the conversation is between approximately the 15-to-17-minute-mark. The transcription for this portion of the conversation is given below:

Samantha : This is étape 1	**Samantha**: This is *step 1*
Jessica : Ok, merci!	**Jessica**: *Ok, thanks!*
Jessica : um... okay hm...	**Jessica**: um...okay hm...
Samantha : étape 3: 'imaginez un atelier que vous pourriez organiser qui s'apprendrait aux habitants de Champaign comment protéger' - what? oh that teaches them how to protect the environment. 'Comment pourriez-vous les convaincre d'adopter des habitudes écolos et vivre une vie plus durable ?'	**Samantha**: étape 3: '*Imagine a workshop that you could organize that would teach the locals of Champaign how to protect*' - what? oh that teaches them how to protect the environment. '*How could you convince them to adopt eco-friendly habits and live a more sustainable life* ?'
Jessica : Hm okay... mmm...	**Jessica**: Hm okay... mmm...
Jessica : donc ... uh comme mon rôle, uhm je suis ou j'ai un atelier - atelier qui apprendra uhm comment économiser de l'eau et d'énergie - de l'énergie	**Jessica**: *so…uh as my role, uhm I am or I have a workshop - workshop which will teach uh how to save some water and some energy - some energy.*
Samantha : oui	**Samantha**: *yes*
Samantha : pour mon rôle, je suis bénévole qui s'est - intéresse à la durabilité. vous souhaitez donc organiser un atelier où vous pourrez apprendre aux gens à vivre.. ok	**Samantha**: *for my role, I am a volunteer who is- is interested in sustainability. 'you therefore wish to organize a workshop where you will teach people to live...'* Ok
Jessica : *laughter*	**Jessica**: *laughter*
Jessica : d'accord d'accord uhmmm okay, uh je pense que um uh li je pense que le plus important chose uhm est que les habitants réduisent la pollution um oui	**Jessica**: *alright alright ummm okay, uh I think that um uh* lik- *I think that the most important thing um is that the locals reduce pollution um yes*

At this point in time, both Samantha (ANX+) and Jessica's (ANX+) heart rates were decreasing and mirroring the findings from the IAM. This is not surprising as the group's conversation had returned to a level 1-2 while they were preparing to go onto step 3 of the activity. Consequently, they were producing less language themselves and relying more on reading the task directions. Therefore, it seems that this break from having to spontaneously produce French lowered their anxiety and subsequently their heart rate.

The last key moment of this activity occurred between approximately the 19-to-22-minute-mark. The transcription for this portion of the conversation is provided below:

Jessica : donc...juste tu as - tu as dit les compagnies ou les entreprises ?	**Jessica**: *so...just you sa - you said companies or businesses*?
Samantha : oui les compagnies oui	**Samantha**: *yes companies yes*
Jessica : donc les - les like entre- ahh les entreprises uh vient à la ate - atelier - a tele. ok, donc c'est c'est la oh my gosh I can't prononce this word c'es- donc la tele - l'atelier - c'est in person ou en personne ? c'est face to face or something like that?	**Jessica**: *so the-the like busin- all the businesses uh comes to the* *work-workshop-shop. ok, so it's it's the* oh my gosh I can't pronounce this word *it so the tv - the workshop - it's* in person *or in person? it's face*-to-face or something like that?
Samantha : mhm	**Samantha**: *mhm*
Samantha : peut-être uh si le covid n'est pas une chose importante ah ou prominente peut-être nous pouvons faire le meeting ? le rendez-vous sur um the -	**Samantha**: *maybe uh if covid is not an important think ah or* prominent *maybe we can do the* meeting ? *the meeting on um* the
Jessica : mhm	**Jessica**: *mhm*
Jessica : ok, d'accord d'accord, uhm j'aime idée. uhmm donc like quelles uh quelles like compagnies ? comme like les restaurants ou like les les compagnies écologiques ou ?	**Jessica**: *ok, alright alright uhm I like idea. uhmm so* like *which uh which companies? like* like *restaurants or* like *environmental companies or?*

Samantha : Oui les compagnies écologiques
Jessica : D'accord um...hm.. donc
Samantha : Nous les pouvons aussi inviter à les scientifiques
Jessica : Like comme like le data et les graphiques et les like comme ça ?
Samantha : Ah oui, les géographes, les biologistes...
Jessica : like
Jessica : oh! ok, okay. Comme les - ils déc- uh oh my gosh ils uh ils uh enseignent les um oh my gosh les effets oh my gosh les effets par uh oui oui le les choses scientifiques plus de progrès, *laughter* plus uhm yeah le plus de data, hm...
Samantha : mhm
Jessica : peut-être um
Samantha : um aussi nous pouvons uh
Jessica : oh did you want to say something? you can go
Jessica : uhm... uh...
Samantha : *inaudible Zoom delay* quoi?
Jessica : wait désolée je ne- je n'entends pas
Samantha : I think uh je pense que *Zoom* se froze for a second
Jessica : Oh okay, yeah *laughter* my uh - mon wifi c'est - c'est mal-mauvaise, mal - c'est mal
Samantha : Oui

Samantha: *Yes environmental companies*
Jessica: *Alright um...hm.. so*
Samantha: *We the can also invite to scientists.*
Jessica: Like *like* like *the* data et *graphs and the* like *like that* ?
Samantha: *Ah yes, geographers, biologists*
Jessica: like
Jessica: oh! ok, okay. *Like the - they dec-uh* oh my gosh *they uh thei uh teach the uh* oh my gosh *the effects by uh yes yes the-the scientific things more of progress *laughter* more uhm hm* yeah *the more of* data, hm..
Samantha: *mhm*
Jessica: *maybe um*
Samantha: *um also we can uh*
Jessica: oh did you want to say something? you can go
Jessica: uhm... uh...
Samantha: *inaudible Zoom delay* *what*?
Jessica: wait *sorry I don' - I don't hear*
Samantha: I think uh *I think that* Zoom froze for a second
Jessica: Oh okay, yeah *laughter* my uh - *my wifi it's - it's badly*-bad, *badly- it's badly.*
Samantha: *Yes*

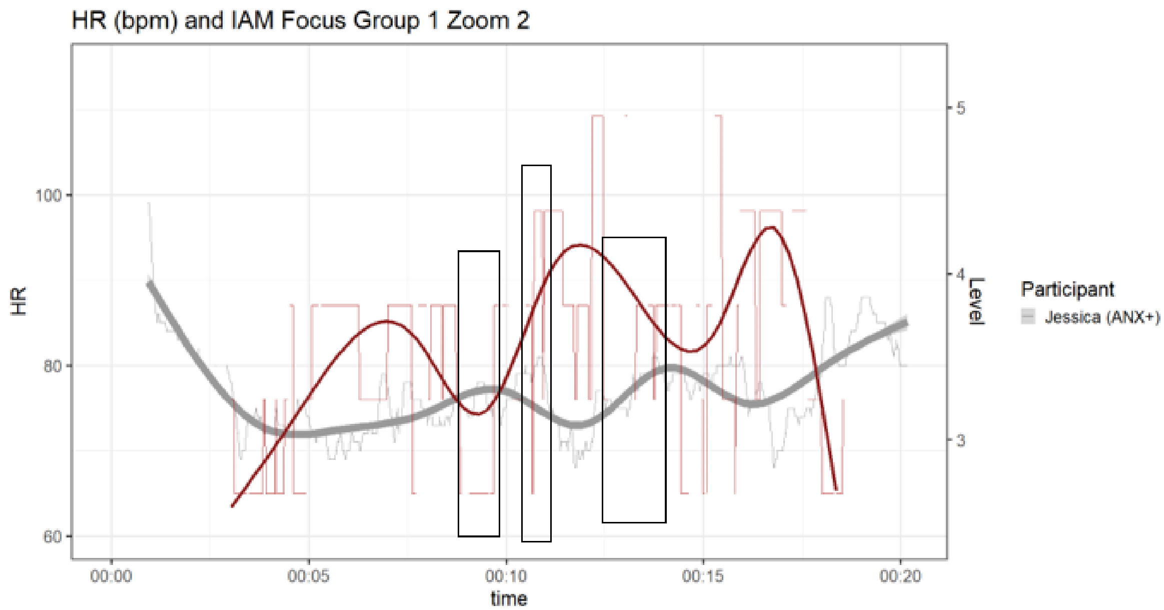
At this point in the conversation, Jessica's (ANX+) heart rate was rising, which is not surprising given that her linguistic breakdowns were typically accompanied by an increase in stress. Moreover, Jessica (ANX+) experienced several linguistic breakdowns during this part of the conversation, specifically when she was trying to pronounce the word "workshop" (*atelier*) in French and when she was clarifying that the scientists would come to explain things to the workshop attendees. However, as Samantha (ANX+) took a more passive role at this time, it was unexpected to see that her heart rate was also rising. Typically, Samantha's (ANX+) heart rate decreased during moments when she did not contribute much to the conversation. Perhaps an explanation is that the Zoom cutout that occurred towards the end of the exchange caused Samantha (ANX+) stress, as it momentarily made communication difficult.

Zoom 2 Task.

Overview.

The second Zoom task that Focus Group 1 completed was about social media. Nick (ANX-) again did not attend class this day. Therefore, Samantha (ANX+) and Jessica (ANX+) worked together to come up with a new type of social media network for young people. They were each given different hierarchical roles during the task, with Jessica (ANX+) being assigned to play Mark Zuckerberg, who was only concerned with creating an addictive, profit-yielding network, and Samantha (ANX+) an intern at Facebook who was worried about creating something that would be too addictive. Over the course of the conversation, Jessica (ANX+) and Samantha (ANX+) ultimately decided to create an educational social network that resembled *TikTok*, in that teachers and professors could post short, educational clips for students to watch.

The unfolding of Samantha (ANX+) and Jessica's (ANX+) coded interaction and heart rate is shown in Figure 35[10].



Key: ☐ : key moments; red line: Interaction Analysis Model
Figure 35. FG1s Zoom 2 Interaction Analysis Levels

For the second Zoom activity, Samantha (ANX+) and Jessica's (ANX+) conversation was at levels 1-2 for the first 2-to-3 minutes of the activity. It then rose briefly to levels 3-4 for the next 4-to-5 minutes, before returning again to levels 1-3. However, around the 10-minute mark, the groups conversation increased to levels 3-4, and eventually to a level-5 (~11 minutes), level-6 (~12 minutes), and level-7 (~13 minutes). It then fluctuated between a level 2-4 for several minutes, before returning again to a level-5 around the 16-minute-mark. Then, around the 18-minute-mark, the group started wrapping up the activity and their conversation fluctuated between levels 1-3 for the remainder of the time.

[10]Samantha's heart rate was not collected during this activity since she forgot to charge her HR monitor before class.

Key Moments.

During this task, Jessica’s (ANX+) heart rate did not coincide as frequently as usual with the IAM findings. In fact, there were several key moments when her heart rate was decreasing, despite the fact that she was expressing a more complex thought. The first moment occurred around the 8-to-9-minute mark. The transcription for this portion of the conversation is provided below:

Samantha : et aider les devoirs - parce que maintenant nous sommes um en ligne sur Zoom et je pense que uh avoir une application qui peut aider uh navig - naviguer uh les uh les uh classes en ligne serait plus utile.	**Samantha**: *and help the homework - because now we are um on line on Zoom and I think that uh to have an application which can help uh navi-navigate uh the uh the uh classes on line would be more useful.*
Jessica : mhm	**Jessica**: *mhm*
Jessica : ohh ok d'accord donc like pour l’éducation ?	**Jessica**: *ohh ok alright so* like *for education*?
Samantha : oui pour l'éducation	**Samantha**: *yes for education*
Jessica : umm hmm	**Jessica** : *umm hmm*
Samantha : j'ai mangé beaucoup de chocolat *laughter* hier et maintenant je me sens trop drousy	**Samantha**: *I ate a lot of chocolate* *laughter* *yesterday and now I feel* trop drousy
Jessica : *laughter* chocolate makes you drowsy *laughter**sigh*	**Jessica**: *laughter* chocolate makes you drowsy *laughter**sigh*
Jessica : je comprends	**Jessica**: *I understand*
Jessica : umm *sigh* 'peut-être *reading inaudibly to self* umm ooo je me souviens beaucoup des like applications ou les-les réseaux sociaux pour - or like pour l'éducation mais je ne - je ne l'utilise pas maintenant	**Jessica**: umm *sigh* *maybe* *reading inaudibly to self* umm *ooo I remember a lot of* like *applications or the-the social networks for* - or like *for education but I don- I don’t use it now.*

Up until this point in the conversation, Jessica's (ANX+) heart rate had remained relatively stable, despite the fact that she had been asking level-4 questions which in other activities led to an increase in heart rate. In this instance though, what triggered an increase in heart rate for Jessica (ANX+) was actually returning to lower levels of discourse in English, when Samantha (ANX+) mentioned that she ate too much chocolate the night before. This is unexpected since we would expect this relief from using French to alleviate anxiety. However, perhaps going off task and talking in English increased anxiety for Jessica (ANX+) since she knew that their group interaction was being recorded and would later be watched by the main researcher.

The second key moment took place from the 10-to-12-minute mark. The transcription of this section of the conversation is given below:

Jessica : peut-être comme like Chegg mais pour mes libres ou no ou par-pas d'ar-da-d'argent	**Jessica**: *maybe like* like *Chegg but for my books or no or through-not mon-mon-money.*
Samantha : uh je pense que ça application doit être free	**Samantha**: *uh I think that that application has to be* free.
Jessica : qu'est-ce que tu penses ?	**Jessica**: *what do you think* ?
Samantha : oh gratuit	**Samantha**: *oh free*
Jessica : gratuit ok	**Jessica**: *free ok*
Samantha : et um sauf peut-être comme - je sais que j'ai dit bust comme TikTok mais on peut le faire comme TikTok mais uh dans un manière moins addictif	**Samantha**: *and um without maybe like - I know that I said* bust *like TikTok but we can do it like TikTok but uh in a less addictive way*
Jessica : ok, d'accord	**Jessica**: *ok, alright*
Samantha : les gens peuvent faire des choses comme TikTok mais choses sur l'éducation, des clips qui sont trop um ourds et avec cette um esthétique de TikTok	**Samantha**: *people can do things like TikTok but things on education, clips that are too um* ourds *and with this um esthetic of TikTok.*

Jessica : d'accord donc like les-les-les vidéos courtes et plus éducatives like comme les like les profs créent les vidéos ou juste like les like étudiants pour s'amuser ? c'est comme ça ?	**Jessica**: *alright so* like *the-the-the short videos and more educational* like *like the* like *the professors create the videos or just* like *the* like *students to have fun? It's like that?*
Samantha : mhm, oui les étudiants et les - um nous pouvons uh faire un section um qui ont des profs qui expliquent le sujet en plus détails et aussi nous pouvons avoir un autre section où ce sont des étudiants qui donnent uh leurs conseils	**Samantha**: *mhm, yes students and the - um we can uh make a section uh which has professors who explain the subject in more details and also we can have another section where it's the students who give uh their advice.*
Jessica : mhm mhm	**Jessica**: *mhm mhm*
Samantha : sur le sujet	**Samantha**: *on the subject*
Jessica : oo ok, je l'aime je l'aime	**Jessica**: *oh ok, I like it, I like it*
Jessica : et donc uh il y a les les uh catégories pour uh like comme like les différentes uh étapes dans l'école et comme ça ?	**Jessica**: *and so uh there are the the uh categories for uh* like *like* like *the different uh steps in school and like that?*

At this point in the conversation, Jessica's (ANX+) heart rate was actively decreasing, even though she was contributing higher level discourse in the form of asking questions (level 4) and clarifying Samantha's (ANX+) position (level 5). In other tasks, Jessica's (ANX+) heart rate increased when she was performing these linguistic functions. Perhaps being on Zoom benefited Jessica (ANX+) by affording her lower anxiety that allowed her to remain calm and in-control when reaching for these more sophisticated contributions in French. Moreover, although Jessica (ANX+) did experience some linguistic breakdown here, characterized by her repetitive use of "like" in English, she did not have as much breakdown as during other tasks. Considering this was also the last consensus-building activity that she did with her group, she could also have become more comfortable completing these types of activities, as indicated by her lower self-reported anxiety score (16). Perhaps this combination of time and course modality led to lower anxiety overall for Jessica (ANX+) and therefore less susceptibility to her anxiety being influenced by these higher levels of discourse.

The third key moment during this task occurred at the 12-to-13-minute mark. The transcription for this portion of the conversation is provided below:

Samantha : oh uh nous pouvons uh faire des différentes applications pour quelques sujets - pour des différents sujets nous pouvons faire l'application pour seulement les mathématiques et dans les mathématiques il peut avoir uh algèbre et géométrie et calculus	**Samantha**: *oh uh we can uh make different applications for some subjects - for different subjects we can make the application for only math and in math it can have uh algebra and geometry and* calculus
Jessica : oo ok - je suis d'accord uh mm ok d'accord	**Jessica**: *oo ok - I agree uh mm ok alright*
Samantha : mhm	**Samantha**: *mhm*
Jessica : donc je pense que il y a aussi like un section pour uh demander les questions peut-être like or like demander un spécifique uh sujet like -u-un sujet spécifique like like les-les triangles ou comme ça	**Jessica**: *so I think that there is also* like *a section to uh to ask questions maybe* like or like *to ask a subject uh specific* like *a-a specific subject* like like *tri-tri-triangles or like that*
Samantha : oui, uh huh	**Samantha**: *yes, uh huh*
Jessica : or som- d'accord ok	**Jessica**: or som- *alright ok*
Samantha : nous pouvons avoir un section um pour la communauté aussi	**Samantha**: *we can have a section um for the community also*
Jessica : mm mhm	**Jessica**: *mm mhm*
Samantha : um	**Samantha**: *um*
Jessica : *whispers* ok	**Jessica**: *whispers* *ok*

At this point in the conversation, Jessica's (ANX+) heart rate was rising, despite the fact that she was not contributing very much and not having much linguistic breakdown. Typically, at these moments, her heart rate would be decreasing. However, watching her and Samantha's (ANX+) video-recorded conversation revealed a reason for which Jessica (ANX+) may have been more anxious at this time. During this time, the researcher had come into Jessica (ANX+) and Samantha's (ANX+) Zoom break out room to check how far they had progressed through the task. Although she was only in the group's breakout room for approximately 15-seconds, it seems that being actively observed by someone who the students viewed as an authority figure contributed to Jessica's (ANX+) anxiety and increase in heart rate.

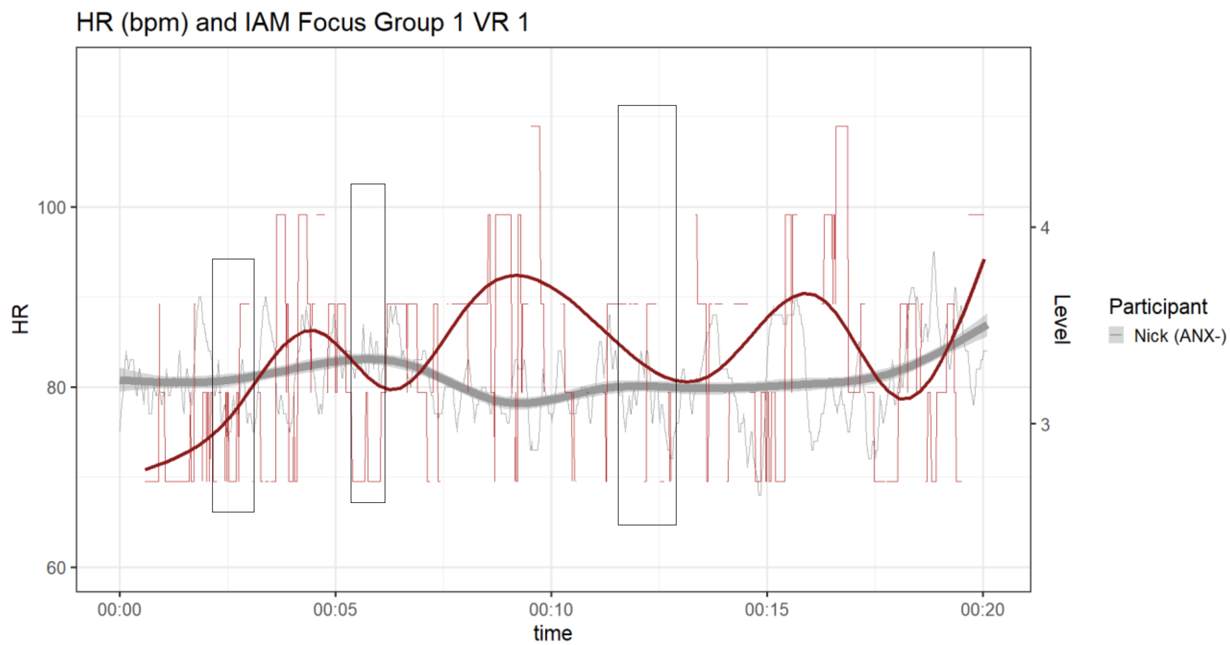
VR 1 Task.

Overview.

The first VR task that Focus Group 1 completed was about *YouTube* channels and trends among the youth. In the task, Nick (ANX-), Samantha (ANX+), and Jessica (ANX+) had to work together to come up with a new *YouTube* Series for the Parisian social media company they all worked for, *Roxane*. They were each given different hierarchical roles during the task, with Jessica (ANX+) being assigned the boss of the company, Samantha (ANX+) an experienced employee, and Nick (ANX-) the new intern of the company. Over the course of the conversation, the group ultimately decided to create a YouTube series that would start in Paris and then focus on traveling around different Francophone parts of the world.

The unfolding of the group's coded interaction and heart rate is shown in Figure 36[11].

[11] Samantha and Jessica's heart rates were not collected during this activity since they did not charge their HR monitors before class.



Key: ☐ : key moments; red line: Interaction Analysis Model
Figure 36. FG1s VR 1 Interaction Analysis Levels

For the first VR activity, the group's conversation was at levels 1-3 for the first 2-to-3 minutes of the activity. It then rose briefly to levels 2-5 for the next 4-to-5 minutes. At approximately 9 minutes and 30 seconds into the conversation, the groups conversation briefly rose to a level-6, and then to a level-7 (~10-minute mark). It then fluctuated between a level 2-4 for several minutes, before increasing to a level-5 around the 15-minute-mark. The group then primarily fluctuated between levels 2-4 for the remainder of the activity.

Key Moments.

Upon triangulating participants' IAM findings, HR data, and video recordings, three key moments were identified pertaining to how Nick's (ANX-) heart rate responded to the unfolding conversation. It should be noted that Nick's (ANX-) heart rate was quite stable throughout the first VR activity, and that it did not tend to fluctuate as much as it did during the two classroom activities, even during situations when we would expect to see changes.

The first key moment when we see Nick's (ANX-) heart rate remain stable despite what was happening during his group's conversation occurred between the 1.5 and 2.5-minute mark. The transcription for this portion of the conversation is provided below:

Nick : Alors, uhh...	**Nick**: *So, uhh...*
Nick : Quelle est - Quelle est votre idée pour la série uh de YouTube ?	**Nick**: *What is - what is your idea for the YouTube uh series?*
Jessica : Mm *clears throat* je pense que uh nous uh uh nous uhh oh my gosh devrait de-choisi um les restaurants uhhh français traditionnels à Paris. Et toi?	**Jessica**: *Mm* *clears throat* *I think that uh we uh uh we uhh* oh my gosh *shoulds de-chose um traditional French uh restaurants in Paris. And you?*
Nick : D'accord c'est- c'est une bonne idée - d'accord uh.... uh...j'aime uh j'aime une série - une série de - des vacances - alors uh par- je veux- je veux partir en vacances pour Paris - uh well pas Paris uh *laughter* *pointing around at VR environment* nous vivons en Paris, uh mais Belgique, uh uh Deutschland, des Etats-Unis, uh Italie et comme uh - et toi Samantha ?	**Nick**: *Alright, that's - that's a good idea. Alright uh...uh...I like uh I like a series -- a vacation of-of series -- to le- I want - I want to go on vacation for Paris* - uh well *not Paris uh* *laughter* *pointing around at VR environment* *we live at Paris, uh but Belgium, uh uh* Deutschland*, of the United States, uh Italy et like uh - and you Samantha?*
Jessica : mmm	**Jessica**: *mmm*

What is remarkable about this portion of the conversation is that Nick's (ANX-) heart rate remained stable while he was speaking even though he experienced linguistic breakdown, characterized by his frequent restarts and repeated use of "uh." This is the opposite of what was observed during the two classroom activities, when linguistic breakdowns seemed to be a source of anxiety for Nick (ANX-) and prompted an increase in heart rate. Perhaps Nick (ANX-) was less susceptible to physiological side effects stemming from difficulties in communication when immersed in the VR environment. Moreover, Nick (ANX-) self-reported his anxiety to be lower in the VR activities, which could have made him less sensitive to changes in heart rate.

The second key moment where we can also see Nick's heart rate remaining stable despite the on-going group conversation occurred right after the 5-minute mark. The transcription for this portion of the conversation is given below:

Nick : uuh je vou- je voudrais uhh beaucoup de saisons pour la série-- uh uh un saison avec - avec 10 épisodes	**Nick** : *uhh I woul- I would like uhh a lot of seasons for the series -- uh uh an season with - with 10 episodes.*
Samantha : moi oui	**Samantha** : *me yes*
Jessica : um dix, mm les dix pour les différentes destinations ou juste like deux - like deux-deux épisodes pour une destination ?	**Jessica** : *um ten, mm the ten for different destinations or just* like *two-* like *two-two episodes for a destination?*
Nick : uh un ou deux épisodes uh en une destination - alors, alors cinq ou dix destinations	**Nick** : *uh one or two episodes uh in a destination - so, so five or ten destinations*
Jessica : Mhm	**Jessica** : *Mhm*
Nick : *sigh*	**Nick** : *sigh*
Jessica : Mhm uh dans like l'Europe ou juste like tout le monde ou ? Non pas tout le monde, artour *laughter* autour du monde ou ?	**Jessica** : *Mhm uh in like Europe or just like everybody or ? No not everybody, airound* *laughter* *around the world or?*
Nick : uh quoi ?	**Nick** : *uh what?*
Julia : *laughter*	**Julia** : *laughter*
Nick : uh, désole *laughter* répétez s'il vous plait	**Nick** : *uh sorry* *laughter* *repeat please*
Samantha : je ne sais pas um	**Samantha** : *I do not know um*
Samantha : peut-etre les destinations francophones ?	**Samantha** : *maybe francophone destinations ?*

Jessica : Okay d'accord, d'accord	**Jessica** : *Okay alright, alright*
Samantha : Comme le Canada et uh les isluhs	**Samantha** : *Like Canada and uh the* isluhs (Islands)
Nick : Ohh !	**Nick** : *Ohh!*
Nick : C'est une bonne idée	**Nick** : *That's a good idea*

Throughout this exchange, Nick's (ANX-) heart rate only barely increased, even though he was negotiating meaning with his peers and specifically Jessica's (ANX+) intended message. Again, this is surprising, considering these types of misunderstandings were found to lead to anxiety in participants during the other tasks. Although Nick (ANX-) had lower FLA in general compared to Samantha (ANX+) and Jessica (ANX+), his heart rate typically still increased during other tasks when he would have to clarify meaning with his peers. The fact that his heart rate remained relatively constant during this portion of the conversation suggests again that Nick (ANX-) is perhaps less sensitive (physiologically speaking) to his anxiety in VR.

The last key moment of this task occurred between the 11-to-12.5-minute mark. At this point in the conversation, the researcher had come into the VR environment to check on participants and make sure that they were not having any trouble. The excerpt of this part of the conversation is provided below:

Nick : Salut !	**Nick**: *Hi !*
Researcher : Bonjour ! ça va ?	**Researcher**: *Hello ! It's going okay?*
Jessica : Salut ! oh oui	**Jessica**: *Hi! Oh yes*
Nick : oui	**Nick**: *yes*
Nick : uh, nous voudrions uh une série uh pour voyager parce que ne- nous voudrions uh - nous voudrions uh partir en vacances	**Nick**: *uh we would like uh a series uh for to travel because we don't - we would like uh we would like uh to go on vacation*
Researcher : C'est bien ! C'est une bonne idée. Où est-ce que vous irez ?	**Researcher**: *That's good! That's a good idea. Where will you go?*

Samantha : À des pays francophones peut-etre	**Samantha**: *To Francophone countries maybe*
Nick : Oui	**Nick**: *Yes*
Nick : Canada et Belgique et uh quel est le mot pour uh the Netherlands ?	**Nick**: *Canada and Belgium and uh what is the word for uh* the Netherlands*?*
Researcher : les Pays-Bas	**Researcher**: *The Netherlands*
Nick : les Pays-Bas ?	**Nick**: *The Netherlands* ?
Samantha : Pays-Bas	**Samantha**: *Netherlands*
Jessica : Hmm	**Jessica**: *Hmm*
Jessica : Umm nous - nous uh n'avons pas uh décidé un - like un thème certain nope un thème *laughter* um - spécifique maintenant mais...	**Jessica**: *Umm we - we uh have not uh decided a* - like *a certain theme* nope *a um* *laughter* *specific theme now but...*
Researcher : mais voyager ça va. c'est un thème	**Researcher**: *But traveling is okay. That's a theme.*
Jessica : Mhm	**Jessica**: *Mhm*
Researcher : C'est très bien en fait.	**Researcher**: *It's very good actually*.
Jessica : Um..nous - nous oh my gosh nous - nous nope *laughter*	**Jessica**: *Um..we* oh my gosh *we* - *we* nope *laughter*
Nick : *laughter*	**Nick**: *laughter*
Jessica : um	**Jessica**: *um*
Nick : Uh voy - répétez la question s'il vous plait	**Nick**: *Uh you - repeat the question please*
Researcher : J'ai pas de questions. Donc vous voyagerez, c'est bien. C'est un bon début umm vous irez dans des pays francophones um qu'est-ce que ferez? Est-ce que vous irez aux restos, aux monuments, aux sites touristiques ?	**Researcher**: *I didn't ask a question. So you will travel, that's good. It's a good start umm you will go to Francophone countries um what will you do? Will you go to restaurants, monuments, tourist sites?*
Jessica : mhm	**Jessica**: *mhm*
Nick : uh	**Nick**: *uh*

Samantha : Ooo je voudrais uh je voudrais uh visiter les sites historiques et les uh et peut-etre explorer les sites uh effrayants ou haunted	**Samantha**: *Ooo I would like uh I would like uh to visit tourist sites and the uh and maybe explore haunted uh sites or* haunted
Nick : Les musées	**Nick**: *Museums*
Jessica : Hmmm	**Jessica**: *Hmmm*
Nick : Les musées aussi et les-les restaurants	**Nick**: *Museums too and restaurants*
Jessica : Mm mm - mais je pense que nous um oo nous um oh my gosh uh devait uh nous devait um oh my gosh faire um quelque chose plus différente que les autres um youtubeurs qui like voyagent um que les autres	**Jessica**: *Mm mm -- but I think that we um we um* oh my gosh *uh had uh we had um* oh my gosh *to do um something more different than the other* uh *youtubers who* like *travel um than the others.*
Nick : C'est plus difficile pour parler français avec une prof non ?	**Nick**: *It's more difficult for speaking French with a professor, isn't it?*
Jessica : *laughter*	**Jessica**: *laughter*

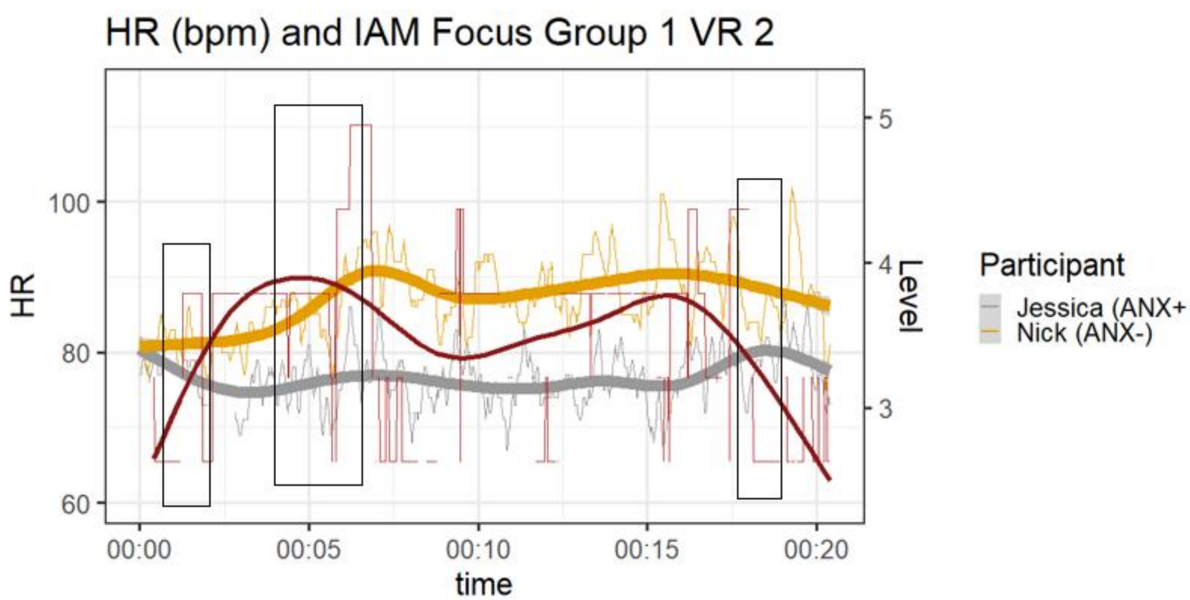
It is clear throughout this exchange that the presence of the researcher was a source of anxiety for the students. Jessica's (ANX+) speech was characterized by significant breakdown, with her struggling to explain that she thought that the group needed to do something different in their series to distinguish themselves from other YouTubers. Nick (ANX-) even vocalized that it was more difficult to speak French when a professor was around. This was not surprising, as Nick (ANX-) often expressed across all environments when he found something to be stressful (e.g., COVID-19 during the first classroom activity and the elections during the second). Interestingly though, although Nick's (ANX-) heart rate slightly increased during this period, it remained relatively stable. This is the opposite of what was observed during the two classroom tasks, when Nick's (ANX-) heart rate increased when he was making these types of comments.

VR 2 Task.

Overview.

The second VR task that Focus Group 1 completed was about education and budget cuts in a school. Samantha (ANX+) did not attend class that day. Therefore, in the task, Nick (ANX-) and Jessica (ANX+) had to work together to decide how necessary budget cuts would be handled in their school system. They were each given different hierarchical roles during the task, with Jessica (ANX+) being assigned Principal of the school and Nick (ANX-) the student representative. Over the course of the conversation, the group ultimately decided to raise the fees that students had to pay for extracurricular activities and to reduce the number of scholarships they were offering to students in order to alleviate financial restraints.

The unfolding of the group's coded interaction and heart rate is shown in Figure 37.



Key: ☐ : key moments Figure #; red line: Interaction Analysis Model
Figure 37: FG1s VR 2 Interaction Analysis Levels

For the first VR activity, the group's conversation was at levels 1-3 for the first 2 minutes of the activity. It then rose to a level-4 and remained here for approximately 5-minutes while Jessica (ANX+) and Nick (ANX-) debated how they should handle the budget cuts. Then, at the 6-

minute-mark, the conversation rose to a level-5 and then a level-6. However, at the 8-minute mark, it dropped to a level-1 and remained between at levels 1-3 for two minutes. Then, the conversation returned to levels 4-5 and eventually to a level 7. Approximately 13 minutes into the task, the group's conversation dropped again to lower levels of discourse (levels 1-3), yet only briefly. A minute later (~14-minute-mark), Jessica (ANX+) and Nick's (ANX-) conversation rose again to levels 4-5 for approximately 5 minutes. It then dropped to levels 2-3 for the last 2 minutes of the conversation.

Key Moments.

Upon merging Jessica (ANX+) and Nick's (ANX-) IAM findings, heart rate data, and transcribed video-recorded conversation, three key moments emerged. The first moment occurred right at the beginning of the conversation during the first 1-2 minutes. The transcription for this portion of the conversation is given below:

Nick : alors um	**Nick**: *so um*
Jessica : je peux commencer	**Jessica**: *I can start*
Nick : le pr-	**Nick**: *the pr-*
Nick : oui oui	**Nick**: *yes yes*
Jessica : c'est ok	**Jessica**: *it's ok*
Jessica :*clears throat* pour - um pour um réduire um les dépenses pour l'école um je pense que um le l'ec- l'école um peut diminuer um le - la technologie qui est dans les salles de classes comme les um comme les Whiteboards et comme les um peut-etre les um *laughter* what else is - well okay, umm oui juste comme les technologies cause le-la technologie est très chère	**Jessica**: *clears throar* *in order to - um in order to um reduce um the spending for the school um I think that um the sch-sch- the school um can reduce um the - technology which is in the classrooms like the um like Whiteboards and like the um maybe the um* *laughter* what else is - well okay, *umm yes just like technologies causes* -- *the - technology is very expensive.*
Nick : très chère	**Nick**: *very expensive*

Nick : oui um je pense la tech - la technologie est très impor non très importante pour les études parce que ils sont très jeunes et le-les jeunes de société uh travaillent bien avec uh technologie alors c'est aussi important pour uh pour uh un moment

Nick : c'est aussi important que les extracurriculaires - c'est très bon pour les pour la-la-les tètes des études uh

Jessica : hmm

Nick : te- tu sais ?

Jessica : oui oui mais je pense que uhh s'il y a les étudiants qui uh qui uh oh my qui uhh n'ont pas fait les uh activités extrascolaires uh très sérieuse uh donc uh c'est beaucoup des dépenses pour uh rien donc je pense que nous nous peut couper les couper quelques extrascolaires

Nick: *yes um I think that tech - technology is very impor - no very important for the studies because they are very young and the youth of society uh work well with uh technology so it's also important for uh for uh a moment*

Nick: *It's also important that the* extracurriculars - *It's very good for the* - *for the- the - the heads of studies uh*

Jessica: *hmm*

Nick: *yo-you know* ?

Jessica: *yes yes but I think that uhh if there are students who uh who uh oh my who uhh didn't do uh extracurricular activities uh very serious uh so uh it's a lot of spending for uh nothing so I think that we-we cans cut the uh cut some extracurricular.*

At this point in time, Jessica's (ANX+) heart rate was decreasing and Nick's (ANX-) was remaining stable. This is interesting, because we would expect to see an increase in heart rate for these two participates during this interaction. Concerning Jessica (ANX+), her heart rate in all other tasks always increased when she had linguistic breakdowns or when she had to talk at length. However, that did not happen here, even though she does have linguistic breakdowns that are characterized by restarts and her saying "oh my." Moreover, Jessica (ANX+) and Nick (ANX-) are disagreeing with each other here regarding the importance of keeping technology in the classroom and extracurricular activities. In previous tasks, notably CR1, we saw an increase in heart rate for participants when disagreements occurred. Furthermore, Nick (ANX-) was also playing a less powerful role -- hierarchically-speaking -- than Jessica (ANX+), which we would expect to contribute to his anxiety when having to argue his position during the conversation. For Nick (ANX-), perhaps conversing within a VR environment led to him having lower anxiety and being less influenced by these types of disagreements during the task. For Jessica (ANX+), it could be that conversing in VR made her less anxious or that playing a more powerful role in the conversation helped her feel more comfortable when arguing.

The second key moment of this conversation occurred between the 4-to-7-minute mark. The transcription of this portion of the conversation is given below:

Jessica : intéressant uh est-ce que tu um est-ce que tu payer paies pour uh joindre le - le club ?	**Jessica**: *interesting uh do you um do you to pay - pay in order to uh to join the - the club?*
Nick : uh oui mais uh pas uh ce semestre parce que *laughter* covid	**Nick**: *uh yes but uh not uh this semester because* *laughter* *covid*
Jessica : mm	**Jessica**: *mm*
Jessica : oui oui oui oui	**Jessica**: *yes yes yes yes*
Jessica : d'accord	**Jessica**: *alright*
Nick : uh nous - nous pouvons pas uh uh sor-sorti-sortons ensemble alors uh ce ce n'est pas important pour uh payer	**Nick**: *uh we - we can not uh uh go - go o- go out together so uh this this is not important in order to uh to pay*
Jessica : mm donc uh uhh donc uh tu penses que tu oh my gosh continueras umm continue to be like continueras aller les - a - aux extrascolaires s'il y a les grands uh oh gosh grands uh pays grands uh grands fees oh gosh désolée j'ai - j'oublie le mot pour fees mais il y a - s'il y a like grands fees?	**Jessica**: *mm so uh uhh so uh you think that you* oh my gosh *will continue umm* continue to be like *will continue to go the - to - to the extracurricular if there are big* uh oh gosh *big uh countries big uh big* fees oh gosh *sorry I hav- I forget the word for* fees *but there are - if there are* like *big* fees?
Nick : umm	**Nick**: *umm*

Nick : *laughter* je ne sais pas aussi um mais uh el - mais extrascolaires uh c'est important pour uh un moment uh tu sais le mot pour 'health' ?

Jessica : mm la sante?

Nick : la santé - la santé de ma tête

Jessica : d'accord d'accord

Nick : uh uh en uh le club- club Boxe, je-je exercice souvent et uh sans - sans ça uh club, uh je *sigh* je-je ne peux pas exercicer

Jessica : mm d'accord donc uh je pense que nous uh continuerons uh le-le même quantité uh d'extrascolaires mais uh peut-etre nous augmente - nous augmentons la paye - le prix pour pour faire les extra-extrascolaires mais pas - pas like trop mais un peu un peu pour aider les um les dépenses à l'école

Nick : hm d'accord

Jessica : *laughter*

Nick : um *hm* désolé uhh

Jessica : you sound so sad *laughter*

Nick : *laughter*

Nick : toujours toujours

Jessica : *sigh*

Nick : *sigh* uhh je suis fatigué

Jessica : non c'est bien c'est

Nick : uh umm je suis fatigué d'école *laughter*

Jessica : *laughter* ouais vrai c'est vrai

Nick : *inhale*

Nick: *laughter* _I do not know also um but uh el- but extracurricular uh it's important for uh a moment uh you know the word for_ 'health'?

Jessica: _mm health_?

Nick: _health - the health of my head_

Jessica: _alright, alright_

Nick: _uh uh in uh the club - boxing club, I- I exercise often and uh without - without that uh club, uh I_ *sigh* _I-I cannot exercise._

Jessica: _mm alright so uh I think that we uh will continue uh the- the same quantity uh of extracurricular but uh perhaps we increases - we increase the pay - the price in order to in order to do the extra-curriculars but not- not like too but a little - a little in order to help the uh the expenses at the school_

Nick: _hm alright_

Jessica: *laughter*

Nick: _um_ *hm* _sorry uhh_

Jessica: you sound so sad *laughter*

Nick: *laughter*

Nick: _always always_

Jessica: *sigh*

Nick: *sigh* _uhh I am tired_

Jessica: _no it's good it's_

Nick: _uh umm I am tired of school_ *laughter*

Jessica: *laughter* _yeah true it's true_

Nick: *inhale*

Nick : c'est difficile like en ligne *sigh* uh alors c'est un bon idée pour uh augmenter le nombre des études en - en classe	**Nick**: *it's difficult* like *on line* *sigh* *uh so it's a good idea to - uh to increase the number of studies in - in class.*
Jessica : oui! je suis d'accord avec ça	**Jessica**: *yes! I agree with that.*
Nick : oui um	**Nick**: *yes um*
Jessica : c'est un bonne idée	**Jessica**: *That's a good idea*
Nick : oui et peut-etre hm uh peut-etre uh modifier uh tout - tous les classes eh uh hm un moment - *laughter* je je - désolé je-je dois penser	**Nick**: *yes and perhaps hm uh maybe uh to modify uh all - all the classes eh uh hm one moment* *laughter* *I-I - sorry I-I have to think.*
Jessica : huh? Ohhh	**Jessica**: *huh? ohhh*
Nick : um	**Nick**: *um*
Jessica : *laughter*	**Jessica**: *laughter*
Nick : *clears throat*	**Nick**: *clears throat*
Nick : toi - tu parles *laughter* parlez s'il vous plait	**Nick**: you - you speak *laughter* talk please.

Throughout this point in the conversation, Jessica's (ANX+) heart rate remained relatively stable and only slightly increased, which could have been caused by the difficulty she experienced when trying to express her ideas. However, the evolution of Nick's (ANX-) heart rate is what makes this moment interesting. Indeed, throughout the 3 minutes, we can see his heart rate consistently increasing, starting from the beginning of the segment when he mentioned how the on-going COVID-19 pandemic was impacting his extracurricular activities. It is clear throughout this exchange that the COVID-19 pandemic was a great source of stress for Nick (ANX-), which is not surprising since we observed a similar reaction during his classroom activities. Moreover, Nick (ANX-) explicitly stated that he was tired of school, and that it was difficult to have classes online. It should also be noted that Nick (ANX-) talked about this moment during his qualitative debriefing interview at the end of the study, saying that this consensus building task "hit really close to home" and that "it would get like a downward spiral with me." Indeed, this "downward spiral" can be seen throughout this exchange, as Nick (ANX-) increasingly became more stressed and ultimately ended up asking Jessica (ANX+) to speak instead of him, saying that he needed a minute to think.

The last key moment of this task occurred between the 18-to-19-minute mark. The excerpt of this part of the conversation is given below:

Nick : *laughter* *referencing his avatar* I was looking uh j'ai - j'ai regardé uh ces chaussures et mes-mes chaussures	**Nick**: *laughter* *referencing his avatar* I was looking uh *I - I looked at uh these shoes and my - my shoes*
Jessica : laughter* um j'aime ton chap- nope j'aime ton chemise the off the shoulder shirt *laughter* c'est très *laughter*	**Jessica**: laughter* *um I like your ha*- nope *I like your shirt* the off the shoulder shirt *laughter* *it's very* *laughter*
Nick : ah!	**Nick**: *ah*!
Nick : *laughter*	**Nick**: *laughter*
Jessica : c'est très uhh très haute	**Jessica**: *It's very uhh very high*
Nick : *laughter* je ne - je ne *laughter* uhh j-je n'ai vu ça	**Nick**: *laughter* *I don't I don't* *laughter* uhh *I not see that*
Jessica : ton style est um impeccable	**Jessica**: *your style is um* impeccable
Nick : m-merci uh c'est-c'est le randomise button	**Nick**: *th-thanks uh it's-its the* randomise button
Jessica : *laughter*	**Jessica** : *laughter*
Nick : uh moment	**Nick**: *uh moment*
Nick : am i a girl?	**Nick**: am i a girl?
Jessica : mm je pense mais tu as l- facial hair	**Jessica**: *mm I think but you have th*- facial hair
Nick : c'est sexiste je *mic cut*	**Nick**: *that's sexist I* *mic cut*
Jessica : ah! oui	**Jessica**: *ah! yes*
Nick : uh tu m'entends ?	**Nick**: *uh you hear me* ?
Jessica : oui oui oui	**Jessica**: *yes yes yes*

Nick : c'est sexiste	**Nick**: *that's sexist*
Jessica : mais - oh oui oh oui	**Jessica**: *but - oh yes oh yes*
Nick : les filles - les filles peuvent uhhh *laughter*	**Nick**: *girls - girls can uhhh* *laughter*
Jessica : c'est vrai *laughter* les filles peuvent	**Jessica**: *that's true* *laughter* *girls can*

At this point in the conversation, Nick's (ANX-) heart rate was decreasing, and Jessica's (ANX+) was increasing. For Nick (ANX-) it could be that this more casual exchange where he was joking with Jessica (ANX+) about his avatar led to lower anxiety. However, for Jessica (ANX+), her heart rate increased the most substantially here when compared to other points in this activity. Perhaps this is because she became anxious when Nick (ANX-) told her she was being sexist by saying his avatar was not female since it had facial hair. Even though Nick (ANX-) said this in a joking manner, perhaps Jessica (ANX+) became anxious thinking that he did indeed perceive her as sexist, and this subsequently led to an increase in her heart rate.

Focus Group 2

Focus group 2 was made up of three participants: Rick (ANX-), Rohan (ANX-), and Amanda (ANX+). In order to provide a better overview of these three participants, their personal background information is presented in Table 22.

Participant	***Gender***	***Age***	***Onset Age of Learning***	***Other Languages***	***Substantial Immersion***
Rick	Male	25	14	--	No
Rohan	Male	20	12	Telegu	No
Amanda	Female	19	0	Korean	Yes

Table 22. Focus group 2 background information

Rick (ANX-) was a 25-year-old male student who started learning French when he was 14 years old. He had no knowledge of any other languages and had no substantial immersion experience.

Rohan (ANX-) was a 20-year-old male student who began learning French at 12 years old. He had no prior immersion experience but knew Telegu. Lastly, Amanda was a 19-year-old female student who started learning French at birth. Indeed, she had extended relatives who were Francophone. She also had knowledge of Korean and substantial immersion experience due to her family.

The results of this group's comprehensibility, intelligibility, and fluency scores, IAM analyses, self-reported anxiety data, and HR data are presented in Table 23.

	Rick (ANX-)						Rohan (ANX-)						Amanda (ANX+)					
IAM	**Z1**	**CR1**	**VR 1**	**Z2**	**CR2**	**VR2**	**Z1**	**CR1**	**VR 1**	**Z2**	**CR2**	**VR 2**	**Z1**	**CR1**	**VR 1**	**Z2**	**CR2**	**VR 2**
Level 1: *Direct Instruction to the Group*	9	3	10	3	5	1	1	4	1	--	2	1		--	2	--		2
Level 2: *Sharing new Information*	13	40	41	15	33	15	16	21	13	10	21	14		10	13	4		13
Level 3: *Situated Definition*	11	17	28	11	33	18	17	1	27	8	38	28		11	16	2		16
Level 4: *Intersubjectivity*	10	3	4	8	6	9	6	1	2	8	5	2		1	7	2		7
Level 5: *Negotiation/ co-construction*	5	--	4	2	2	6	2	--	2	--	--	2		--	4	2		4
Level 6: *Testing Constructions*	--	--	--	1	--	--	--	--	--	--	--	--		--	6	--		6
Level 7: *Reporting New Knowledge*	--	--	1	--	--	--	--	--	--	--	--	--		--	2	--		2
Total Turns	48	63	**88**	40	79	49	42	27	45	26	**66**	47		22	**50**	10		**50**
Comprehensibility	7.44	7.78	7.67	7.89	**8.11**	7.89	6.56	**6**	**5**	7.56	**7**	**6.78**		8.33	8.33	8.33		**8.44**
Intelligibility	84.9	81.5	**91.2**	83.7	82.2	82.4	74	70.3	74.4	**82.6**	78.1	87.1		77	79.7	**90.4**		82
Fluency	14.3	13	17	**21.7**	15.7	19.7	13	13	15	14	14	**19**		29	14.7	23.7		**32**
Self-Reported Anxiety	16	**11**	18	**11**	**11**	16	24	22	22	23	22	22		28	29	32		**25**
Baseline HR (bpm)	--	60.4	67.8	65.0	81.8	66.8	65.9	73.6	74.3	60.0	65.2	76.7		83.7	74.4	84.9		93.4
Mean HR (bpm)	--	64.2	62.9	67.5	88.5	66.7	70.2	70.5	67.6	57.6	65.8	77.3		83.9	69.6	86.2		88.1
SD HR (bpm)	--	5.0	4.2	6.0	3.4	5.5	6.1	5.2	5.1	6.4	4.9	5.2		3.8	6.1	4.4		3.8

Key: VR1: virtual reality task 1; CR1: classroom task 1; Z1: zoom task 1; VR2: virtual reality task 2; CR2: classroom task 2; Z2: zoom task 2; gray shade: absent for task.

Table 23. Interaction Analysis Model (Hull & Saxon, 2009) focus group 2.

Regarding Rick (ANX-), the number of times he contributed to the group's conversation was the highest in VR1 (88), followed by the classroom tasks (CR2 = 79; CR1 = 63) and then VR2 (49), Zoom1 (48), and Zoom2 (40). Interestingly, aside from in the classroom environment, Rick (ANX-) talked less in each environment overtime. Moreover, the number of times that Rick (ANX-) contributed to a conversation did not seem to be necessarily tied to his self-reported anxiety. Indeed, Rick (ANX-) self-reported the highest anxiety during the VR1 task yet spoke the most during this activity. Concerning his level of discourse, Rick (ANX-) reached high, complex levels (i.e., levels 6 and 7) in the VR1 and Zoom2 tasks.

Rick's mean HR was highest during the CR2 task (88.5 bpm), followed by the Z2 (67.5 bpm), VR2 (66.7 bpm), CR1 (64.2 bpm), and VR1 (62.9 bpm) tasks. Compared to his baseline, Rick had an *increase* in HR during the CR1 (3.8 bpm), Z2 (2.5 bpm), and CR2 (6.7 bpm) tasks, and a *decrease* from his baseline for the VR1 (4.9 bpm) and VR2 (.1 bpm) tasks.

Concerning Rohan (ANX-), the number of times he spoke was highest in the CR2 task (66), followed by VR2 (47), VR1 (45), Zoom1 (42), CR1 (27) and Zoom2 (26). Therefore, he increased the amount he spoke in the VR and classroom environments over time but did not do so in the Zoom environment. Moreover, Rohan's (ANX-) self-reported anxiety (22) remained stable throughout all CR and VR activities and was only barely higher in the Zoom1 (24) and Zoom2 (23) activities. Moreover, Rohan (ANX-) reached higher, complex levels of discourse (i.e., level 5) during the VR1, VR2, and Zoom1 tasks.

Rohan's mean HR was highest during the VR2 task (77.3 bpm), followed by the CR1 (70.5), Z1 (70.2), VR1 (67.6), CR2 (65.8), and Z2 (57.6) tasks. Compared to his baseline, Rohan had an *increase* in HR during the Z1 (4.3 bpm), CR2 (.6 bpm), and VR2 (.6 bpm) tasks, and a *decrease* from his baseline for the CR1 (3.1 bpm), VR1 (6.7 bpm), and Z2 (2.4 bpm) tasks.

For Amanda (ANX+), the number of times she contributed to the group's conversation was highest in the VR tasks (50), followed by CR1 (22) and Zoom2 (10). This finding somewhat mirrors her self-reported anxiety, with Amanda (ANX+) being the least anxious in the VR2 task (25), followed by CR1 (28), VR1 (29), and Zoom2 (32). Finally, Amanda (ANX+) reached her highest levels of discourse (i.e., levels 6 & 7) during the VR1 and VR2 tasks.

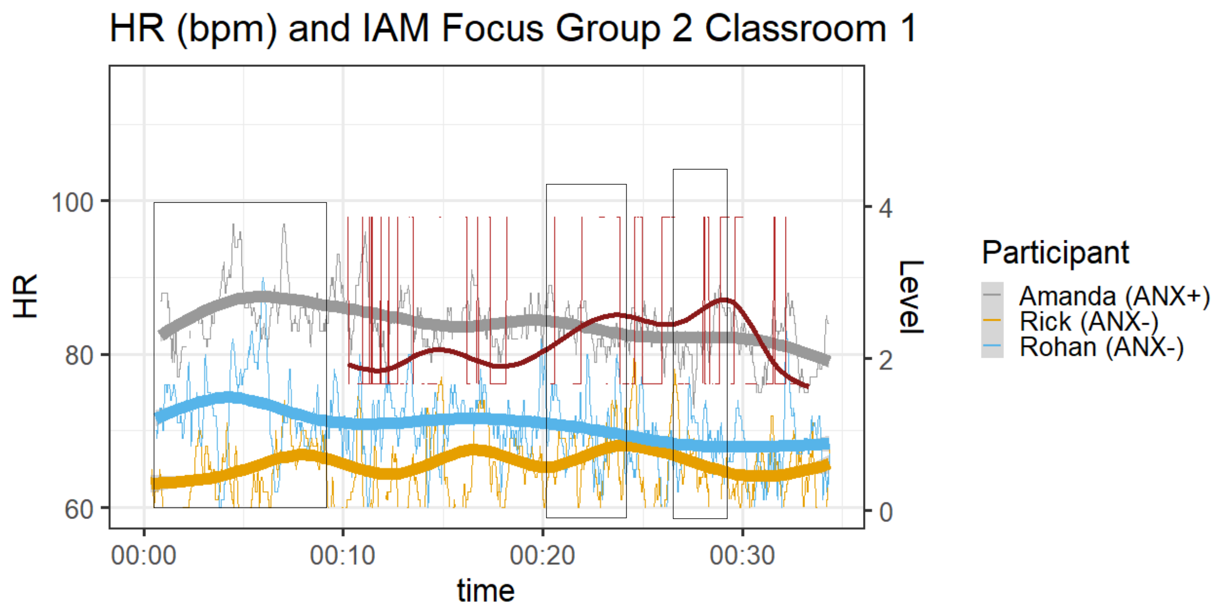
Amanda's mean HR was highest during the VR2 (88.1 bpm) task, followed by the Z2 (86.2 bpm), CR1 (83.9 bpm), and VR1 tasks (69.6 bpm). Compared to her baseline, her HR increased during the CR1 (.2 bpm) and Z2 (1.3 bpm) tasks but decreased during the VR1 (4.8 bpm) and VR2 (5.3 bpm) tasks.

Classroom 1 Task.

Overview.

The first classroom task that Focus Group 2 completed dealt with the subject of technology. For their consensus building activity, Rick (ANX-), Rohan (ANX-), and Amanda (ANX+) had to come up with a technology that could solve an existing problem in society. They were each assigned different hierarchical roles during the task, with Rick (ANX-) being assigned to play a Ph.D. student in engineering at the *Université de Sorbonne*, Rohan (ANX-) a professor of engineering at the same university, and Amanda (ANX+) the CEO of the biggest technology developer in Paris. Over the course of the conversation, the group ultimately decided to create an algorithm that could locate underserved communities with the aim of then dedicating more resources to these locations.

The unfolding of Rick (ANX-), Rohan (ANX-), and Amanda's (ANX+) coded interaction and each participant's heart rate is shown in Figure 38.



Key: [ ] : key moments; red line: Interaction Analysis Model
Figure 38. FG2s Classroom 1 Interaction Analysis and Heart Rate Levels

For the first classroom activity, the group took ten-minutes before starting to converse with each other. During this time, they each were taking individual notes on their own pieces of paper. Only once the main researcher prompted them for a second time to begin discussing the activity did they do so. Then, their conversation remained at lower levels of discourse. Specifically, the group's conversation was at a level 1-3 for the majority of the activity. It only sporadically rose to a level-4 three times: at the 14-, 19-, and 27-minute marks.

Key Moments.

Upon triangulating participants' heart rate and IAM data with the video and transcription data of their conversation, three key moments emerged when participants' heart rates fluctuated in response to their unfolding conversation.

The first key moment occurred at the very beginning of the activity, from approximately the 1-to-9-minute mark. At this time, we see all participants' heart rates rising during the first half of this segment before falling towards the end. These fluctuations are interesting, as participants were not actually conversing with each other or working collaboratively on the activity. Instead, they were working independently in complete silence. Since participants were not producing French, we would expect to see either a decrease or stability in heart rate. However, perhaps participants felt pressure from not getting started on the activity together which could have contributed to fluctuations in anxiety throughout these few minutes.

The second key moment occurred between the 20-to-24-minute mark. An excerpt of participants' conversation at this point in time is given below:

Rohan : risque .... um	**Rohan**: *risk .... um*
Rick : un risque um peut-etre uh une personne peut exploiter le algorithme uh voler uhh la	**Rick**: *a risk um maybe uh a person can exploit the algorithm uh to steal uhh the*
Rohan : oh oui	**Rohan**: *oh yes*
Amanda : mhm	**Amanda**: *mhm*
Rick : umm	**Rick**: *umm*
Amanda : uh aussi si ou de plus si il y a une uh j'ai oublié le mot pour mistake mais si il y a un problème avec l'algorithme ou le code des uh - oui les-les numéros pour l'argent pour chaque compte um peut-etre...	**Amanda**: *uh also if or of more if there is a - uh I forgot the word for* mistake *but if there is a problem with the algorithm or the code of uh yes the-the numbers for the money in each account um maybe...*
Rick : ouais	**Rick**: *yeah*
Rick : malfonctionne?	**Rick**: *malfunction* ?
Rick : ouais c'est c'est bonne idée	**Rick**: *yeah that's* - *that's a good idea*
Rick : uhh il y a les autres idées?	**Rick**: *uhh are there other ideas?*

At this point in the conversation, Rohan (ANX-) and Amanda's (ANX+) heart rates were decreasing, and Rick's (ANX-) heart rate was increasing. It is not surprising that Rohan (ANX-) had a decrease in heart rate, especially considering he did not really contribute to the conversation at this time. However, it is surprising to see a decrease in Amanda's (ANX+) heart rate. Amanda (ANX+) was contributing the most to the conversation here and also verbally expressed that she forgot the word for "mistake." These types of difficulties in communication typically led to increases in heart rate for other ANX+ participants (Jessica & Samantha), particularly in the classroom environment. However, perhaps Amanda's (ANX+) ability to circumnavigate this issue by reformulating her utterance to use the word "problem" (*problème*) prevented her from experiencing an increase in anxiety at this time. Concerning Rick (ANX-), it was surprising to see that he experienced an increase in heart rate at this moment, especially considering he did not contribute much to the conversation or experience much linguistic breakdown. However, it should be noted that Rick (ANX-) was leading the group's conversation at this point, which can be seen when he prompts Rohan (ANX-) and Amanda (ANX+) for any additional ideas. Consequently, perhaps Rick (ANX-) felt internal pressure that contributed to an increase in heart rate at this time.

The last key moment of the group's conversation occurred between the 26 and 28-minute mark. The transcription for this portion of the conversation is given below.

Amanda : uh pour un technologie mal je crois que j'ai entendu j'ai oublié quand mais une fois j'ai entendu que uh il y a- il y avait les gens qui ont essayé de développer une uh je ne sais pas expliquer en français mais une face scanning ou un algorithme pour um déterminer qui sont les qui ou qui va umm faire des crimes oui et l'algorithme était plus raciste parce que it would juste regarde les visages um noires et carre non vie et uh décider « oh il va commit des crimes, il va commit des crimes »

Amanda: *uh for a technology bad I believe that I heard - I forgot when but once I heard that uh there are - there were people who tried to develop a uh I don't know how to explain in French but a* face scanning *or an algorithm for um to determine who are the - who or who are going um to do crimes yes and the algorithm was more racist because* it would *just look at black um faces and care not life and uh to decide "oh he is going commit crimes, he is going commit crimes"*

Rick : ouais c'est c'est effrayant um il est il est très cr-creepy um aussi um c'est très raciste um il y a il y a plus um facons de de trouver des criminiels - criminels um par la visage c'est fou	**Rick**: *yeah it's it's scary um it is* - *he is very* cr-creepy *um also um it's very racist um there are - there are more um ways of- of finding criminials - criminals um by the face it's crazy*
Amanda : mhm, oui	**Amanda**: *mhm, yes*
Rohan : mhm, oui	**Rohan**: *mhm, yes*
Rick : umm ouais uh c'est c'est uh définitivement un grand problème um qui est um qui est levé	**Rick**: *umm yeah uh it's it's uh definitely a big problem um which is um which is raised*
Rick : uhhh le gouvernement um uh peut espionner - espionnage um par les téléphones ou le internet	**Rick**: *uhhh the government um uh can spy - spying um by telephones or the internet*
Rohan : mhm	**Rohan**: *mhm*
Amanda: mhm	**Amanda** : *mhm*
Rohan : oui *whispers something to self*	**Rohan**: *yes* *whispers something to self*
Rick : oui oui uh je ne pense pas um que c'est l'intelligence artificielle. c'est juste um espionnage normale *laughter*	**Rick**: *yes yes uh I don't think um that it's artificial intelligence. It's just um normal spying* *laughter*
Rohan : *laughter*	**Rohan**: *laughter*
Rick : uh pour Alexa um est-ce que vous pensez que c'est plus bien ou pl- uh pardon pl-c'est mieux ou moins uh	**Rick**: *uh for Alexa um do you think that it's more well or mo- uh sorry mo- it's better or less uh*
Rohan : je n'ai pas une uh Alexa mais je pense que il est plus bon	**Rohan**: *I don't have a uh Alexa but I think that it is more good.*

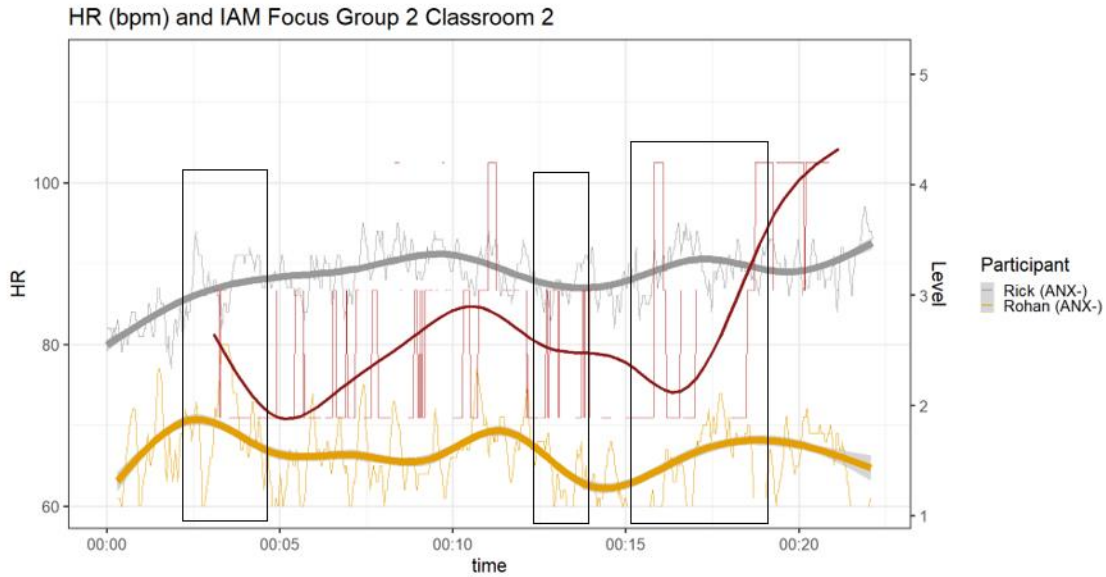
At this point in time, Rick (ANX-) and Rohan's (ANX-) heart rates were decreasing, and Amanda's (ANX+) was remaining stable. This is surprising, because this was the point in the conversation where the group hit their highest level of discourse for longer than one, singular utterance (level 4). Therefore, we would expect this increase in complexity to trigger an increase in anxiety for participants, especially Amanda who is ANX+. However, unlike Focus Group 1, who often had significant linguistic breakdowns when reaching higher levels of interaction, Rick (ANX-), Rohan (ANX-), and Amanda (ANX+) were still communicating with relative ease. Perhaps the few linguistic breakdowns that did occur (e.g., Rick (ANX-) trying to ask if Alexa is better or worst) were not enough to trigger a physiological response. Moreover, even though this was the highest level of discourse that the group reached during this task, they were still only conversing at a level 4. Perhaps higher, more complex levels of discourse (e.g., levels 6-7) would have led to an increase in anxiety.

Classroom 2 Task.

Overview.

The second classroom task that Focus Group 2 completed dealt with the subject of the 2024 Paris Olympics. For their consensus building activity, Rohan (ANX-) and Rick (ANX-) worked to come up with a plan for organizing the Olympic games in Paris in 2024. Amanda (ANX+) did not attend class that day. Rick (ANX-) and Rohan (ANX-) were each asked to play different hierarchical roles during the task, with Rick (ANX-) being given the president of the planning committee and Rohan (ANX-) the treasurer. Over the course of the conversation, the group ultimately came up with a plan for the 2024 Olympics, while considering sanitary and financial constraints.

The unfolding of Rick (ANX-) and Rohan's (ANX-) coded interaction and each participant's heart rate is shown in Figure 39.



Key: : key moments; red line: Interaction Analysis Model
Figure 39. FG2s Classroom 2 Interaction Analysis and Heart Rate Levels

For the second classroom activity, the group took 3 minutes before getting started. Then, their conversation fluctuated between levels 1-3 until 11 minutes into the activity when it rose to a level 4. However, it then returned to levels 2-3 until rising again briefly to level 4 at the 16-minute-mark and level 5 at the 17.5-minute mark. It then fluctuated between levels 3 and 4 for the last few minutes of the activity.

Key Moments.

Upon triangulating participants' heart rate and IAM data with the video and transcription data of their conversation, three key moments emerged when participants' heart rates fluctuated in response to their unfolding conversation.

The first key moment occurred right at the beginning of the conversation, between the 2.5 and 5 minute-mark. The transcription for this portion of the conversation is given below:

Rick : donc uh je pense que les JO soient importants parce que um c'est c'est le plus grand évènement pour les sports métiers um um beaucoup de ces sports um um uhh ils ils sont pas un lieu de publique donc uh c'est bien.	**Rick**: *so uh I think that the Olympic Games are important because um it's it's the biggest event for sports jobs um um a lot of these sports um um uhh they they are not a public place so uh it's good.*
Rohan : mm. ouais	**Rohan**: *mm. yeah*
Rohan : aussi je pense que um ils représentent um le ... *silence* *hand gesture* le beaucoup de pays um	**Rohan**: *also I think that um they represent the ...* *silence* *hand gesture* *the a lot of countries um*
Rick : ouais	**Rick**: *yeah*
Rohan : comme une organisation	**Rohan**: *like an organisation*
Rick : ouais um c'est bien pour um crier des des lieux um...	**Rick**: *yeah um it's good to um scream some some places um...*
Rohan : communauté	**Rohan**: *community*
Rick : ouais ouais ouais exactement	**Rick**: *yeah yeah yeah exactly*
Rick : um um ça représente ça *laughter* umm je pense que ils représentent aussi um le santé en général um	**Rick**: *um um that represents that* *laughter* *umm I think that they represent also um health in general um*

Throughout this portion of the conversation, Rick's (ANX-) heart rate increased during the moments when he was speaking and remained lower when listening to Rohan (ANX-). Rohan's (ANX-) heart rate followed a similar pattern. However, what is interesting about this moment is that Rohan's (ANX-) heart rate peaked the highest it had throughout the entire activity, right at the moment when he was unable to find his words and using gestures. This is interesting, as there were other later moments in the conversation when he was also unable to express himself and yet he did not have this type of reaction. Perhaps the fact that the activity had just begun and that the group was just warming up in French contributed to him having a stronger reaction to this type of incident.

The second key moment occurred later in the conversation, between the 12.5 and 14 minute-mark. The transcription for this portion of the conversation is given below:

Rohan : il y a un - une stade de football et uh une stade de pour le basket et um je pense que une pool I dont know what it's called	**Rohan**: *there is a - a football stadium and uh a stadium of for basketball and um I think that a* pool I don't know what it's called
Rick : uhh piscine?	**Rick**: *uhh pool?*
Rohan : ouais ouais	**Rohan**: *yeah yeah*
Rick : je pense. um ouais uhh	**Rick**: *I think. um yeah uhh*
Rick : ils peuvent utiliser aussi um le- le fleuve um Sien	**Rick**: *they can also use um the the river um Sien*
Rohan : ouais	**Rohan**: *yeah*
Rick : Sienne? um pour pour faire du natatiation	**Rick**: *Sienne? um to to do swimmiming*
Rohan : mhm	**Rohan**: *mhm*
Rick : mm	**Rick**: *mm*
Rick : extérieur - extérieur de Paris	**Rick**: *outside - outside of Paris*
Rohan: ouais ouais ouais dans le uhh le countryside le	**Rohan**: *yeah yeah yeah in the uhh the* countryside *the*
Rick : uhh	**Rick**: *uhh*
Researcher : la campagne	**Researcher**: *the countryside*
Rohan : le ouais ouais uh avec le ouais dans le campagne	**Rohan**: *the yeah yeah uh with the yeah in the countryside*

Throughout this point in the conversation, both Rick's (ANX-) and Rohan's (ANX-) heart rates remained relatively low and stable, despite the fact that they were both having trouble expressing themselves, particularly with Rick (ANX-) struggling to remember the name of the *Seine* River and Rohan (ANX-) forgetting the words for "pool" (*piscine*) and "countryside" (*campagne*) in French. This is therefore contrary to what we would expect to see, particularly after Rohan's

(ANX-) sharp rise in heart rate earlier in the conversation when he was unable to find the appropriate words to express himself. Perhaps an explanation could be that the short utterances both participants were contributing helped keep their physiological anxiety lower. In other words, the fact that neither Rick (ANX-) nor Rohan (ANX-) were speaking at length or trying to express a more complex thought could have combatted any anxiety that stemmed from forgetting vocabulary.

The last key moment of this activity occurred between the 15-to-18-minute mark. The transcription for this portion of the conversation is presented below:

Rick : c'est difficile parce que um si l'évènement utilise um uh le like distance sociale um puis um il peut pas um ven-vender - uh vendre? vender uhh beaucoup des des reces - reces donc uh ça peut um blesser uh le la crise financière?	**Rick**: *it's difficult because um it the event uses um uh le* like *social distance um then um it can not um se-selle-uh sell? selle uhh a lot of of reces-reces so uh that can um hurt uh the the financial crisis?*
Rohan : mhm. ouais	**Rohan**: *mhm. yeah*
Rohan : mhm et je pense que aussi et le je pense que le COVID uh ne sera une uh problème en uh dans quatre ans	**Rohan**: *mhm and I think that also and the I think that COVID uh not will a uh problem in uh in four years*
Rick : ouais uh j'espère *laughter*	**Rick**: *yeah uh I hope* *laughter*
Rohan : ouais donc uh pour la santé de tout le monde uh je pense que on utilise le comme uh protocols et uh patients? dans le dans le dans les JO uh en Venesuale	**Rohan**: *yeah so uh for the health of everyone uh I think that we use the like uh protocols and uh patients? in the in the in the Olympic Games uh in Venezuela.*
Rick : ouais. mm	**Rick**: *yeah. mm*
Rick : hmm il peut um arre - arrêtre um des - des avertissements pour um uh laver des mains um porter le masques etc.	**Rick**: *hmm it can um sto-stopper um some - some warnings for um uh wash hands, um wear masks, etc.*

Rohan : ouais	**Rohan**: *yeah*
Rick : hmm	**Rick**: *hmm*
Rick : umm à mon avis um uh deux mille vingt-quatre est trop uh loin um uh trop loin de maintenant donc uh um il est difficile de prédire um les - la situation um de l'avenir	**Rick**: *umm in my opinion um uh two thousand and twenty four is too uh far um uh too far from now so uh um it is difficult to predict um the - the situation um of the future*
Rohan : ouais	**Rohan**: *yeah*
Rick : donc um il est mieux de rester uhh ouais	**Rick**: *so um it is better to stay uhh yeah*
Rick : uhh je pense que um il est possible uh de remettre à plus tard um c'est - c'est mieux que um c'est mieux que um annuler les JO en entièreté	**Rick**: *uhh I think that um it is possible uh to push back to later um it's -it's better than um it's better than um cancelling the Olympic Games in entirety*

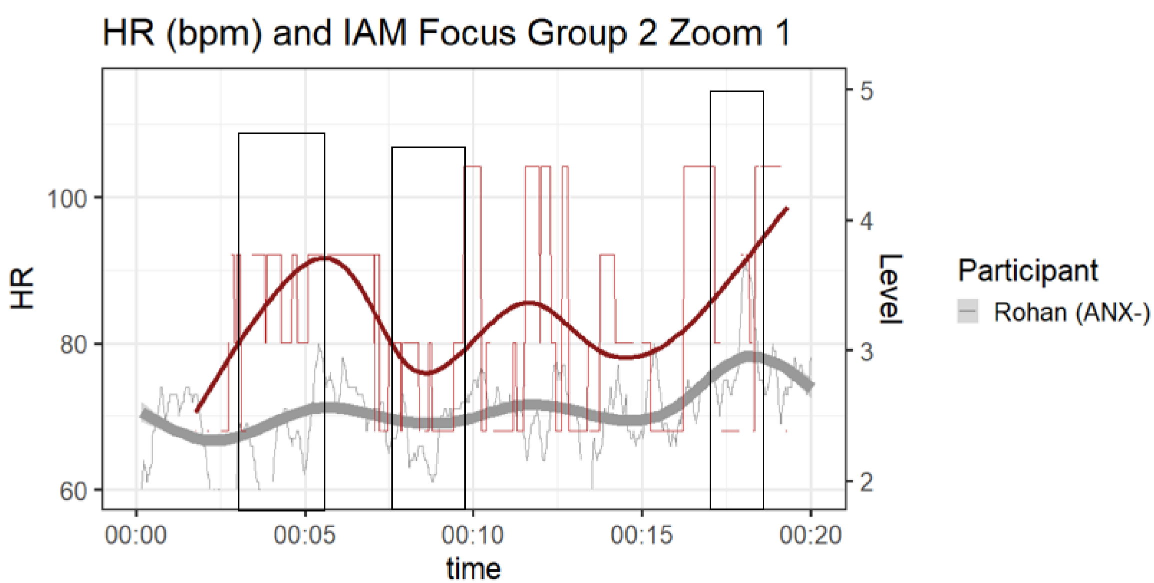
Throughout this portion of the conversation, Rick's (ANX-) and Rohan's (ANX-) heart rates rose and fell in tandem with when they were speaking. For example, when Rick (ANX-) was explaining at the beginning of the dialogue that social distancing could make the financial crisis worse, his heart rate was also rising. Likewise, when Rohan (ANX-) tried to explain how he did not think COVID-19 would still be an issue in 2024, his heart rate also rose. It should also be noted that although there were some hesitations and restarts, the group was ultimately able to converse quite easily throughout this portion of the conversation. This reiterates the idea found in the 2nd key moment of this task: that speaking at length and making longer contributions to the conversation (i.e., a clear sign of advancing proficiency) increased anxiety, and subsequently heart rate, for Rick (ANX-) and Rohan (ANX-), even though they were ANX- participants.

Zoom 1 Task.

Overview.

The first Zoom task that Focus Group 2 completed was about YouTube channels and trends among the youth. Amanda (ANX+) did not attend class on that day. Therefore, in the task, Rick (ANX-) and Rohan (ANX-) worked together to come up with a new YouTube Series for the Parisian social media company they both worked for, *Roxane*. They were each given different hierarchical roles during the task, with Rohan (ANX-) being assigned the boss of the company and Rick (ANX-) the new intern of the company. Over the course of the conversation, the group ultimately decided to create a YouTube series that would spotlight traditional French restaurants in Paris.

The unfolding of the group's coded interaction and heart rate is shown in Figure 40[12].



Key: ☐: key moments; red line: Interaction Analysis Model
Figure 40. FG2s Zoom 1 Interaction Analysis and Heart Rate Levels

[12]Rick's heart rate was not collected during this activity since he did not charge his HR monitor before class.

For the first *Zoom* activity, the group’s conversation fluctuated between levels 1-3 for the first 3 minutes of the activity. Then, it quickly rose to a level 4, and fluctuated between levels 3-4 until approximately 7-minutes into the activity, before returning to levels 2-3. Then, around 10 minutes into the activity, the group’s conversation rose to a level 5 and jumped between levels 2-5 for the next few minutes. It then returned to lower levels (levels 2-3) until the end of the conversation when it rose to level 5 again (~17 and ~19 minute-marks).

Key Moments.

Upon triangulating Rohan’s (ANX-) heart rate and IAM data with the video and transcription data of the conversation, three key moments emerged when his heart rate fluctuated in response to him and Rick’s (ANX-) unfolding conversation.

The first key moment occurred at the beginning of the conversation, between the 2.5 and 5 minute-mark. The transcription for this portion of the conversation is given below:

Rick : um mon - mon idée uh pour Rohan, c'est ummm, faire une série sur la cuisine végane donc ah, on peut parler, umm um de resto um végan um tout le monde um, ouais ouais	**Rick**: *um my - my idea uh for Rohan it’s ummm to do a series on vegan cuisine so ah, we can talk, umm umm about um vegan um restaurant um everyone um yeah yeah*
Rohan : ok uh, c'est bon ah idea, idée, mais uh … pour uh pour les les gens de Paris, je pense que uh, une thème de classique et uh um	**Rohan**: *ok uh, it’s good ah* idea *idea, but uh...for uh for the the people of Paris, I think that uh a classic of theme and uh um*
Rick : Ouais, ah la cuisine classique um, c'est peu um, c'est peu relatée? *laugh* ah, ou les gens plus bien que les restos végans	**Rick**: *Yeah, ah classic cuisine um, it’s little um it’s little related?* *laugh* *ah, or people more good than vegan restaurants.*
Rohan : ouais. mhm	**Rohan**: *yeah. mhm*
Rohan : um-hum c'est major- c'est majorité de de les gens est n'est pas uh végan	**Rohan**: *um-hum it’s major - it’s majority of of people is - is not uh vegan.*

Rick : Ouais ouais, uh uh um, le um, la naissance um carne carne ? et bien, donc, um c'est c'est une bonne idée, um um.

Rick: *Yeah yeah, uh uh um, le um, the birth um* carne carne ? *and well, so, um it's it's a good idea, um um.*

Rohan : oui

Rohan: *yes*

Rick : Qu'est-ce que on parle um en le série um plus spécifique um par exemple um, la préparation de la cuisine, ou umm um les restos en particulaire um ah ou autre?

Rick: *What do we talk um in the series um more specific um for example um the preparation of food, or ummm um the restaurants in particular um ah or other?*

What is interesting about this particular moment is that Rohan's (ANX-) heart rate unfolded in the opposite direction of what we would expect to see. Typically, participants' heart rates have shown to increase when they were speaking and to decrease when listening to other participants. However, over the course of this segment, Rohan's (ANX-) heart rate was actually lower when he was talking (at the beginning) before increasing substantially when Rick (ANX-) was speaking at the end. Perhaps there are two possible explanations for this: the first being that Rohan (ANX-) could have had trouble understanding Rick (ANX-), who was not expressing himself very clearly, and consequently experienced an increase an anxiety. A second explanation could be that Rohan (ANX-) became anxious when Rick (ANX-) prompted him at the end of this segment with a question. Since Rohan (ANX-) typically played a more passive role during the group's activities, perhaps Rick (ANX-) explicitly asking him to talk about what they could focus on in the *YouTube* series increased his anxiety.

The second key moment occurred at the beginning of the conversation, between the 7.5 and 9.5 minute-mark. The transcription for this portion of the conversation is given below:

Rick : Um il y a … il y a plusieurs uh spécialités ah, de la cuisine française, donc ah, c'est, um pardon, ça devrait pas difficile

Rick: *Um there are...there are several uh specialties ah of French cuisine, so ah, it's, um sorry, this not should difficult to find*

de trouver les sujets. Il y a coq au vin, um, foie sauvignon, um, etcetera.	*subjects. There is coq au vin, um liver sauvignon, um, etcetera.*
Rohan : oui	**Rohan**: *yes*
Rick : *Laugh*, Il y a une pastry en Bretagne qui, um, qui est juste la sucre et la beurre, c'est terrible pour la santé, mais j'ai entendu que, c'est um goût, um c'est goût sa goût um bien	**Rick**: *Laugh*, *There is a* pastry *in Brittany which, um, which is just sugar and butter, it's terrible for health, but I heard that, it's a taste, um it's a taste, it's taste um well.*
Rohan : hmm, umkay	**Rohan**: *hmm, umkay*
Rick : *Laugh*, umm	**Rick**: *Laugh*, *umm*
Rohan : um	**Rohan**: *um*
Rohan : je pense que nous pouvons um moite uh moite uhh ha- half? moite	**Rohan**: *I think that we can um hal- uh hal- uhh* ha-half? *have?*
Rick : demi ?	**Rick**: *half* ?
Rohan : Demi! Demi um uh les épisodes um intradit- um uh … les épisodes um like une minu- hold on um. Demi les épisodes um restaurants um français traditionnels et autre demi um restaurants uh …. branchés ? Hip ? Branché ?	**Rohan**: *Half! Half um uh the episodes um forbid- um uh... the episodes um* like *one minute*-hold on *um. Half the episodes um restaurants um traditional French and other half um restaurants uh....trendy?* Hip? *Trendy?*

In this segment, Rohan's (ANX-) heart rate unfolded as we would expect, decreasing when he was not talking and increasing at the end when he was trying to express that half of the episodes of their *YouTube* series could be on traditional French restaurants and the other half on newer, trendier restaurants. This is what we would expect to see, and it is not surprising that Rohan's (ANX-) heart rate increased throughout him speaking, particularly because he had trouble expressing himself. Indeed, the fact that Rohan (ANX-) hesitated as he was not sure of himself and questioned whether "*la moitié*" and "*branché*" were the correct words for "half" and "trendy" could have contributed to his anxiety and increased his heart rate.

The last key moment occurred right at the end of the conversation, between the 18 and 19.5 minute-mark. The transcription for this portion of the conversation is given below:

Rohan : Okay, devrions-nous créer une budget ou uh ou um nous n'avons pas besoin uh le budget ?	**Rohan**: *Okay, should we create a budget or uh or um we do not need uh the budget?*
Rick : um ?	**Rick**: *um* ?
Rohan : Budget est « le budget »	**Rohan**: *Budget is* "budget"
Rick : oh oh, um ouais uh un budget uh est nécessaire mais um … ah je sais pas *laugh*…um	**Rick**: *oh oh, um yeah uh a budget uh is necessary but um … ah I don't know* *laugh*…*um*
Rick : Um combien um est-ce que un caméra um coûte ?	**Rick**: *Um how much um does a camera uh cost?*
Rohan : ummm	**Rohan**: *ummm*
Rick : moins de une mille ? ou plus ?	**Rick**: *less of a thousand? or plus?*
Rohan : pour le entièreté de projet, ou ?	**Rohan**: *for the entirety of the project, or* ?
Rick : ah non, non, juste - juste une bonne caméra	**Rick**: *ah no, no, just - just a good camera.*
Rohan : oh ouais uh, je pense que ouais… il est - il est bon	**Rohan**: *oh yeah uh , I think that yeah...it is - it is good*

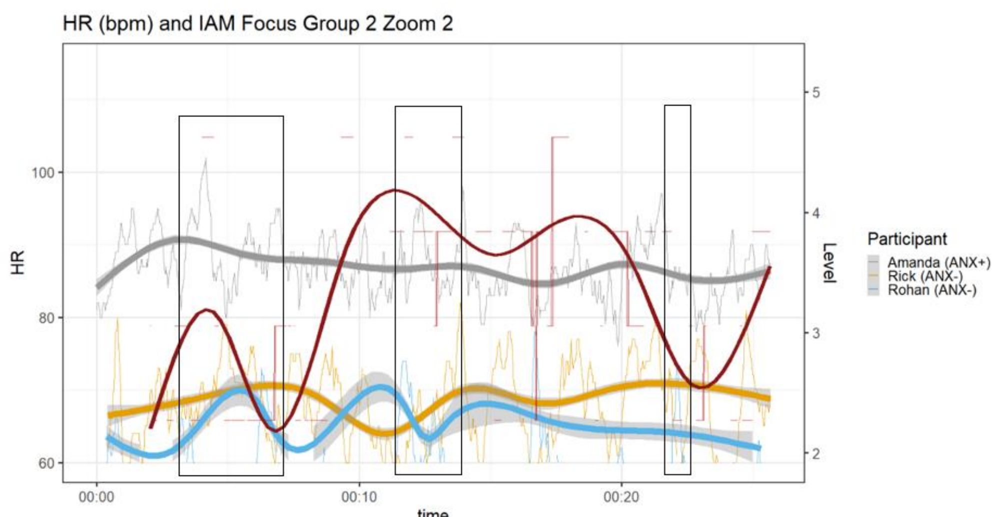
Throughout this segment, Rohan's (ANX-) heart rate spiked to the highest it had been during the activity. This was initially surprising, since neither he nor Rick (ANX-) were talking at length or contributing very complex thoughts. However, upon further examining the *Zoom* recording and transcript, it was found that this moment coincided with when the researcher had messaged all students to let them know that they would be returning shortly from their breakout rooms to have an entire class discussion. While it cannot be confirmed that Rohan (ANX-) for sure saw this message, perhaps realizing that him and Rick (ANX-) would have to soon return and present their ideas to the class momentarily increased his anxiety and, consequently, his heart rate. Indeed, research has shown that a main contributing factor to FLA is fear of negative evaluation by one's peers (Aslan & Sahin, 2020; Boudreau et al., 2020; Dewaele & Dewaele, 2017; Fondo et al., 2018; Ipek, 2016; Khoroshilova, 2016; Maria-Signona & Barros-Del Rio, 2016; Shirvan & Talebzadeh, 2020; Vo et al., 2017; Zheng & Cheng, 2018). Although Rohan was an ANX- participant, he could still have been susceptible to worrying about speaking French in front of his classmates or the researcher.

Zoom 2 Task.

Overview.

The second Zoom task that Focus Group 2 completed was about education and budget cuts in a school. In the task, Amanda (ANX+), Rick (ANX-), and Rohan (ANX-) had to work together to decide how necessary budget cuts would be handled in their school system. They were each given different hierarchical roles during the task, with Rohan (ANX-) being assigned Principal of the school, Rick (ANX-) a teacher in the school, and Amanda (ANX+) the student representative. Over the course of the conversation, the group ultimately decided to save money by increasing the number of students and reducing the amount of technology in each class.

The unfolding of the group's coded interaction and heart rate is shown in Figure 41.



Key: : key moments; red line: Interaction Analysis Model
Figure 41. FG2s Zoom 2 Interaction Analysis and Heart Rate Levels

For the second *Zoom* activity, the group's conversation fluctuated between levels 1-3 for the first few minutes of the activity, before rising to level 4 at the 4-minute-mark. It then returned to levels 2-3 until approximately 9.5 minutes into the activity. At that point, it rose to a level 5 and then fluctuated primarily between levels 4-5 for the next 10 minutes. At 19 minutes into the activity, the group's conversation returned to lower levels (2-4) for the remainder of the conversation.

Key Moments.

Upon triangulating the group's heart rate and IAM data with the video and transcription data of the conversation, three key moments emerged when participants' heart rates fluctuated in response to the unfolding interaction.

The first key moment occurred during the first 3.5 to 6 minutes of the conversation. The transcription from this point of the conversation is provided below:

Amanda : Umm pour moi la meilleure option est d'augmenter le nombre des étudiants dans chaque classe uh et utilise plus de technologie pour enseigner uh à plus d'étudiants en même temps	**Amanda**: *Umm for me the best option is to increase the number of students in each class uh and use more technology to teach uh to more students at the same time.*
Rick : Uh je pense que um à mon avis il est un mauvais idée uh d'augmenter uh les étudiantes en une cours parce que il est plus difficile um d'enseigner les étudiantes um parce que um il y a plus étudiantes.	**Rick**: *Uh I think that um in my opinion it is a bad idea uh to increase uh the students in a class because it is more difficult um to teach the students um because there are more students.*
Rohan : Oui um j'accord uh avec uh Rick.	**Rohan**: *Yes um I am agree uh with uh Rick.*
Rick : Réduire les activités uh extrascolaires uh c'est-c'est pas pratique-practical parce que um c'est-c'est common de d'épuiser plus argent personnel pour ces activités um par	**Rick**: *Reducing extracurricular uh activities uh it's-it's not practical*-practical *because um it's-it's common to wear out more personal money for these activities um for*

exemple si or s'il peut um faire de-de foot um il-il doit or il faut um donner um plus argent. Um c'est-c'est pas uh libre.	*example if* or *if he can um play so-soccer um he-he has or it's necessary um to give um more money. Um it's-it's not uh free.*
Rohan : Um pour moi, je-je préfère ne pas réduire le nombre de uh um scholar-scholarships parce que um uh les scholarship uh permettent uh la um les étudiants uh not-pas beaucoup d'argent de venir au lycée. Je pense que il uh il est nécessaire pour les uh les étudiants.	**Rohan**: *Um for me, I-I prefer to not reduce the number of uh um* scholar-scholarships *because um uh* scholarships *uh allow uh the - um students uh* not *not a lot of money to come to high school. I think that it uh it is necessary for the uh the students.*
Amanda : Um pour moi je préfère ne pas réduire les activités scolaires parce que uh je pense que sont bon pour la santé mentale des étudiants.	**Amanda**: *Um for me I prefer to not reduce the curricular activities because uh I think that are good for the mental health of students.*

Throughout this portion of the conversation, we see a clear pattern of participants' heart rates rising when they are expressing their points of view. Indeed, Amanda's (ANX+) heart rate notably increased twice: primarily at the beginning when she was saying that she thought the best idea was to increase the number of students in each class, but also at the end when she argued that reducing extracurricular activities could be harmful to students' mental health. For Rick (ANX-), we see a marked increase in heart rate the first time he spoke, when he was countering Amanda's (ANX+) idea to increase the number of students in each class. We also see a slight increase in heart rate when Rick (ANX-) was trying to explain that extracurricular activities are not free. Finally, concerning Rohan (ANX-), his heart rate was relatively stable throughout this portion of the conversation, as he did not contribute much. However, his heart rate did increase the one time he gave his opinion on the importance of scholarships.

The second key moment occurred from 11.5 to 14.5 minutes into the conversation. The transcription from this point of the conversation is provided below:

Rohan : Ok que pensez-vous que uh nous devrions um faire uh concern-concernement um le nombre de étudiants dans le um la dans la dans-dans chaque uh classe ?
Amanda : Uh j'ai dit que c'est la meilleure option de augmenter le nombre des étudiants dans chaque classe pour enseigner à plus des étudiants en même temps mais
Rohan : Ah à mon avis ah aug-augmenter le nombre de étudiants um uh n'est pas du tout possible parce que um il y a déjà trop uh d'étudiants uh dans uh la classe um et um il est uh difficile pour les um pour uh les professeurs pour um uh d'enseigner
Rick : Uh oui je suis d'accord um. Um ça-ça peut être difficile um pardon je-je- peut-être une problème uh si il y a trop des étudiants en le cours uh parce que uh le enseignant um peut pas um focuser *laughs* uh uh focuser um sur les étudiants qui ont besoin de la plus um assis-assistance
Amanda : Uh je crois que s'il y a plus des étudiants dans une classe quand le professeur ne peut pas faire attention à quelques étudiants les autres étudiants peut s'aident ou peu-peut aide oui
Rick : Uh il y a une cours qui est moins uh le moins important qui um pardon um la quel on peut éliminer peut-être. Uh je connais um or je sais que beaucoup des

Rohan: *Ok what do you think that uh we should um do uh concern-conceringly um the number of students in the um the in the in-in each uh class?*
Amanda: *Uh I said that it's the best option to increase the number of students in each class to teach to more students at the same time but*
Rohan: *Ah in my opinion ah incr-increasing the number of students um uh is not at all possible because um there are already too uh many students uh in uh the class um and um it is um difficult for the um for uh the professors for um uh to teach.*
Rick: *Uh yes I agree um. Um that-that can be difficult um sorry I-I- maybe a problem uh if there are too many students in the class uh because uh the teacher um can't um* focuser *laughs* *uh uh* focuses *um on the students who need the most um ass-assistance.*
Amanda: *Uh I believe that if there are more students in a class when the professor can not pay attention to some students, the other students cans to help each other or ca-cans help yes*
Rick: *Uh there is a class which is less uh the least important which um sorry um the - which we can eliminate perhaps. Uh I am familiar with um* or *I know that a lot of*

jeunes uh pense que le P.E. est pas important à école.	*young people uh thing that* P.E. *is not important at school.*

Throughout this exchange, participants' heart rates did not always mirror the unfolding conversation. Indeed, there were moments when participants' heart rates increased when they were speaking but others when their heart rate remained low despite the fact that we would expect to see an increase. Specifically, concerning Rohan (ANX-), his heart rate increased when he initially addressed the group by asking what they thought they should do about the number of students in each class. This increase was not surprising, as Rohan's (ANX-) heart rate typically increased when he would speak and also since he was taking on a leadership role at this point in the conversation. Interestingly though, Rohan (ANX-) did not have an increase in heart rate the second time he spoke, even though he had linguistic breakdown, characterized primarily by restarts and the use of "um," when trying to express himself. Regarding Amanda (ANX+), she also had an increase in heart rate the first time she spoke, but not the second time. This was surprising, since Amanda was an ANX+ participant who would frequently be stressed when having to speak. Moreover, in this key moment, participants were at a level 4 and expressing divergent points of view, which we would expect to have triggered anxiety. Therefore, perhaps an explanation for Rohan (ANX-) and Amanda's (ANX+) more stable heart rates here could be that they become more comfortable as the activity went along in the virtual environment and were less susceptible to increases in anxiety that stemmed from speaking.

The third key moment occurred right around the 22-minute-mark. The transcription from this segment of the conversation is given below:

Rohan : Comment-comment dit-on uh like how do you say outweighs ? Um les-les coûts um plus de le bien de technologie. Does that make sense ? Like um	**Rohan**: *How-how do you say uh* like how do you say outweighs? *Um the-the costs um more of the good of technology*. Does that make sense ? Like *um*

Rick : *After looking up the translation* Took me a second but uh c'est-c'est comment uh il-il be um outweigh en français.	**Rick**: *After looking up the translation* Took me a second but uh *it's-it's how uh it-it* be *um* outweigh *in French.*
Rohan : Re-répétez	**Rohan**: *Re-repeat*
Rick : C'est en chat um c'est-c'est uh outweigh en français	**Rick**: *It's in chat um it's-it's uh* outweigh *in French.*
Rohan : Oh ok, I see. Ok les uh les coûts uh l'emporter sur le bien de um technologie à mon avis.	**Rohan**: Oh ok, I see. *Ok the uh the costs uh prevail over the good of um technology in my opinion.*

During this portion of the conversation, the only participant whose heart rate was increasing was Rohan (ANX-). This is not surprising, as he was contributing the most to the conversation at this point in time. Moreover, in this instance, Rohan's (ANX-) increase in heart rate seems to have been triggered by his inability to express himself. Indeed, we can see Rohan's (ANX-) heart rate actively increasing as he tries to figure out how to say that the cost of pedagogical technology outweighs any benefit of it.

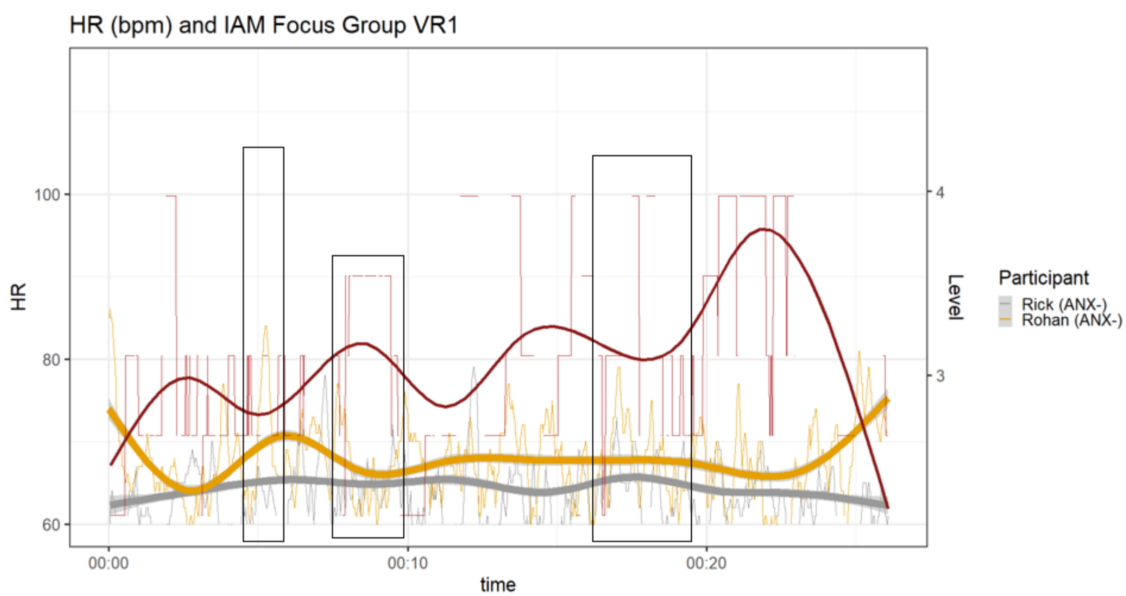
VR 1 Task.

Overview.

The first VR task that Focus Group 2 completed centered around the subject of the environment. Amanda (ANX+) did not attend class this day. Therefore, for their activity, Rick (ANX-) and Rohan (ANX-) worked together to organize a workshop on sustainability that would teach the local people of Champaign how to be more mindful of the environment. They were each given different hierarchical roles during the task, with Rick (ANX-) being assigned to play the Director of *The Champaign County Sustainability Network* and Rohan (ANX-) a volunteer of the organization. Over the course of the conversation, Rick (ANX-) and Rohan (ANX-)

ultimately decided that the workshop would focus on reducing pollution and that they would ask companies to adopt necessary measures to protect the environment.

The unfolding of Rick (ANX-) and Rohan's (ANX-) coded interaction and heart rate is shown in Figure 42. For the first VR activity, the group's conversation fluctuated between levels 1-3 for the first two minutes of the conversation, before quickly jumping up to a level 5 at the two-minute mark. It then returned to levels 2-3 until 8 minutes into the conversation. At this point, it rose to a level 4 and remained here for two minutes before dropping again to levels 2-3, and briefly to a level 1 (~10 minute-mark). However, 12 minutes into the task, the conversation rose again briefly to a level 5 before returning to levels 2-3. The conversation then fluctuated between levels 2-5 for several minutes. Closer to the end of the activity (~18.5 minute-mark), the conversation remained relatively stable at a level 2-3 until the 20-minute mark. At that point, it rose again to a level 5 for the majority of the rest of the conversation.



Key: : key moments; red line: Interaction Analysis Model
Figure 42. FG2s VR 1 Interaction Analysis and Heart Rate Levels

Key Moments.

Upon triangulating the group's heart rate and IAM data with the video and transcription data of the conversation, three key moments emerged when participants' heart rates fluctuated in response to the unfolding interaction.

The first key moment occurred approximately 4.5 minutes into the task. The transcription for this portion of the conversation is provided below:

Rick : Um ouais uh je-je t'accord um il y a aussi um les gens uh les gens peuvent utiliser moins de voitures - voitures um ils - ils peuvent um utiliser err conduire um un vélo	**Rick**: *Um yeah uh I-I agree you um there are also um people uh people can use less cars - cars um they - they can um use err drive um a bike*
Rohan : Mm. Conduire. Ouais	**Rohan**: *Mm. To drive. Yeah*
Rick : Contre	**Rick**: *Against*
Rohan : Uh comment dit-on ... oh sorry	**Rohan**: *Uh how do you say...* oh sorry
Rick : Contre le-le - Oh no problem go ahead	**Rick**: *Against the-the-* Oh no problem go ahead
Rohan : Uh comment dit-on uh uh uh 'carpool'	**Rohan**: *Uh how do you say uh uh uh* 'carpool'
Rick : Ohh. Je sais pas *laughing*	**Rick**: *Ohh. I don't know* *laughing*
Rohan : Okay *laughter*	**Rohan**: *Okay* *laughter*
Rick : Umm ahh maybe just conduire des voitures ensemble or conduire ensemble	**Rick**: *Umm ahh* maybe just *to drive cars together* or *to drive together*
Rohan : Ouais ouais	**Rohan**: *Yeah yeah*
Rick : Go together. Drive together? I dunno *laughter*	**Rick**: Go together. Drive together? I dunno *laughter*
Rohan : Oui	**Rohan**: *Yes*
Rick : Ouais c'est-c'est une bonne idée	**Rick**: *Yeah that's-that's a good idea*

Throughout this interaction, Rick's (ANX-) heart rate remained relatively low whereas Rohan's (ANX-) peaked. In fact, Rohan's (ANX-) heart rate was at its highest point during this moment of the conversation. Although Rohan (ANX-) was unable to remember the word for “carpooling” in French (*covoiturage*), it was still surprising to see his heart rate substantially increase at this time, particularly since he was working collectively with Rick (ANX-) to come up with a way to say “carpool.” Moreover, Rohan (ANX-) was also not expressing longer, complex thoughts which are typically what had peaked his anxiety and heart rate in the past. Perhaps an explanation could be that this exchange occurred relatively early on during the task which could have resulted in Rohan (ANX-) not being warmed up and consequently being more nervous.

The second key moment occurred from the 7.5 to 10-minute mark. The transcription for this portion of the conversation is provided below:

Rick : On continue um à le étape 3 ou...	**Rick**: *We continue um to the step 3 or...*
Rohan : Deux ?	**Rohan**: *Two*?
Rohan : Trois. Okay	**Rohan**: *Three. Okay*
Rick : Ou seulement un et deux ?	**Rick**: *Or only one and two* ?
Rohan : Okay	**Rohan**: *Okay*
Rick : Uhh c'était une question *laughter*	**Rick**: *Uhh it was a question* *laughter*
Rick : Uhhh on continue	**Rick**: *Uhhh we continue*
Researcher : Donc qu'est-ce que vous avez dit pour étape 2 ?	**Researcher**: *So what did you say for step 2*?
Rick : Uh répétez s'il vous plait	**Rick**: *Uh repeat please*
Researcher : Qu'est-ce que vous avez dit pour étape 2 ?	**Researcher**: *What did you say for step 2?*
Rick : Umm	**Rick**: *Umm*
Rohan : Oh	**Rohan**: *Oh*
Rick : Uh les gens peuvent conduire ensemble en voiture	**Rick**: *Uh people can drive together in car.*
Rohan : Uh nous uh utilisons uh nous ne utilisons pas uh beaucoup de-de l'eau uh unnécessaire et uh nous recy-recyclons ?	**Rohan**: *Uh we uh use uh we do not use uh a lot of-of the water uh* unnecessary *and uh we recl-recycle?*

Rohan : Umm ou Rick a dit um uh nous uh electer uh les-les uh les gens dans le gouvernement pour protecter uh le environnement	**Rohan**: *Umm or Rick said um uh we uh to elect uh the-the uh people in the government in order to* protecter *uh the environment*

Throughout this exchange, Rick (ANX-) and Rohan's (ANX-) heart rates both remained low. This was surprising, as the researcher was present with the students at this time. With Focus Group 1, we saw that participants' heart rates would increase when the researcher was present. Indeed, fear of negative evaluation by peers or teachers is one of the leading contributors to FLA. However, this effect was not observed on Rick (ANX-) and Rohan (ANX-). Perhaps the fact that Rick (ANX-) and Rohan (ANX-) were both ANX- participants could have led to them being less susceptible to an increase in anxiety when the researcher would check in on them during tasks.

The last key moment of this task directly contrasts the second key moment and occurred between the 16 and 18.5-minute-mark. The transcription for this portion of the task is provided below:

Rick : Um les gens peuvent uh uh peuvent faire uh faire uh faire la va-vaisselle uh sans uh sans la machine uh un autre mot uh uh ils-ils se lavent par des mains contre la machine uh je pense que c'est utiliser moins d'eau	**Rick**: *Um people can uh uh can do uh do uh do the dis-dishes uh without uh without the machine uh another word uh uh they-they wash themselves by hands against the machine uh I think that it's to use less water*
Rohan : Hmm	**Rohan**: *Hmm*
Rohan : Okay	**Rohan**: *Okay*
Rohan : Hmm	**Rohan**: *Hmm*
Rick : Hmm	**Rick**: *Hmm*
Rohan : Umm	**Rohan**: *Umm*
Rick : Hmm	**Rick**: *Hmm*
Rohan : Umm	**Rohan**: *Umm*

Rick : Je pense que um les gens uh les gens conduit uh ensemble est une bonne idée que-que tu as dit
Rohan : Mhm
Rohan : Ouais
Rohan : Umm
Rick : Hm, umm

Researcher leaves

Rohan : Pour le réduire le pollution um les gens uh pouvons uh *mumbles under breath* what's the word I'm looking for?
Rohan : Oh nevermind, nevermind
Rick : Uhh les gens
Rohan : Pour - comment dit - comment dit-on - I'm blanking on this word. Oh my god.

Rick: *I think that um people uh people drives uh together is a good idea that-that you said*
Rohan: *Mhm*
Rohan: *Yeah*
Rohan: *Umm*
Rick: *Hm, umm*

Researcher leaves

Rohan: *To the reduce pollution um people uh cans uh* *mumbles under breath* what's the word I'm looking for?
Rohan: Oh nevermind, nevermind
Rick: *Uhh people*
Rohan: *For - how say - how do you say* - I'm blanking on this word. Oh my god.

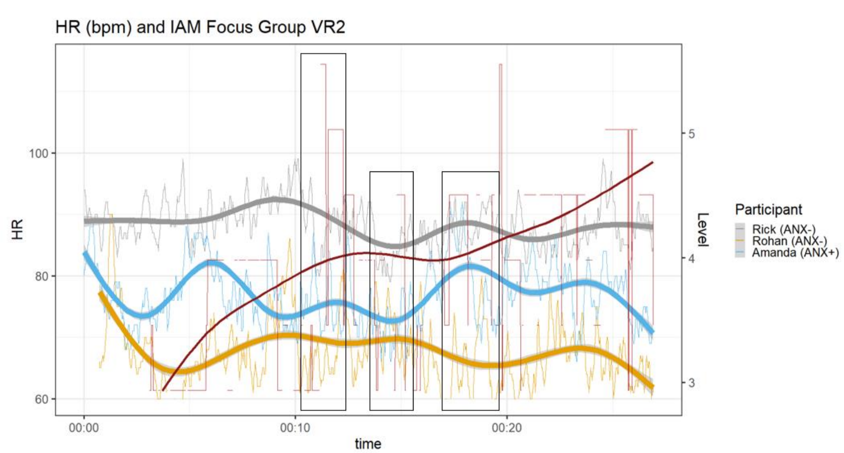
At this point in the conversation, the researcher had returned to check on the group and see how far along they were with the task. In order to not disturb Rick (ANX-) and Rohan (ANX-), she briefly joined the VR environment and then left after noting the group's progress. For Rick (ANX-), the researcher joining did not seem to impact his anxiety, as his heart rate remained relatively low during this time. This parallels what we saw during the second key moment of this task. However, for Rohan (ANX-), his heart rate spiked during this time, clearly indicating an increase in anxiety. Moreover, Rohan (ANX-) seemed to completely shut down and would not converse with Rick (ANX-) even when Rick (ANX-) tried to encourage him to do so by referencing an idea that Rohan (ANX-) had had earlier. In fact, Rohan (ANX-) did not say anything aside from one-word utterances until after the researcher left the VR environment. Moreover, the video footage reveals that Rohan (ANX-) was only looking at the researcher at this time and not Rick (ANX-) who was speaking to him. While it is clear that the researcher joining led to anxiety for Rohan (ANX-), it is unclear why this moment impacted him so much compared to what was seen during the second key moment. Perhaps the fact that the researcher was not directly interacting with the students but instead silently observing increased Rohan's (ANX-) anxiety. Or perhaps Rohan (ANX-) knew already that he could not remember the word that he needed to express himself and he was afraid of performing poorly in front of the researcher.

VR 2 Task.

Overview.

The second VR task that Focus Group 2 completed dealt with social media. For their activity, Rick (ANX-), Rohan (ANX-), and Amanda (ANX+) worked together to come up with a new type of social media network that the youth would enjoy. They were each given different hierarchical roles during the task, with Rick (ANX-) being assigned to play Mark Zuckerberg, Rohan (ANX-) a long-term Facebook employee, and Amanda (ANX+) an intern. Over the course of the conversation, the three students ultimately decided to create a new social network called *RAR* that would help people make friends in their local community.

The unfolding of the group's coded interaction and heart rate is shown in Figure 43.



Key: : key moments; red line: Interaction Analysis Model
Figure 43. FG2s VR 2 Interaction Analysis and Heart Rate Levels

For the second VR activity, the group's conversation fluctuated between levels 1-3 for the first few minutes of the conversation, before quickly jumping up to a level 4 around the six-minute mark. It remained here for three minutes before returning again to levels 2-3. 11 minutes into the activity, the group's conversation briefly reached a level 7 and then levels 6 and 5. At the 13-minute-mark, it descended to a level 4, before briefly dropping to levels 2-3, and returning to level 4 at the 14-minute mark. It then briefly rose again to a level 5, before dropping to levels 2-3. It then fluctuated between levels 3-5 until the 20-minute mark. At 20-minutes into the activity, it briefly reached a level 7, before fluctuating again between levels 3-5 until the 25-minute mark. At this point, the groups conversation rose to a level 5-6 for the last few minutes of the conversation.

Key Moments.

Upon triangulating the group's heart rate and IAM data with the video and transcription data of the conversation, three key moments emerged when participants' heart rates fluctuated in response to the unfolding interaction.

The first key moment occurred from minutes 11 to 12 of the conversation. The transcription from this point of the conversation is provided below:

Amanda : Donc on va créer une réseau sociaux pour par- comme *Instagram* et *Tiktok* pour partager les uh les memes *laughter* et les images ?
Rohan : Mhm
Amanda : Parce -
Rick : Ouais ouais um il - pardonne-pardonne-moi go ahead
Rohan : Ouais

Amanda: *So, we are going to create a socials network for by- like Instagram and Tiktok in order to share the - uh memes* *laughter* *and images?*
Rohan: *Mhm*
Amanda: *Becau -*
Rick: *Yeah yeah um it - pardon-pardon me* go ahead
Rohan: *Yeah*

Amanda : Oh oh parce que um j'aime l'idée de créer un réseau sociaux pour trouver des amis et je crois que les gens peuvent faire des um profils avec les-les-les images ou même les *Tiktoks* que-qu'ils aiment et les autres gens dans-dans le area - je ne sais pas le mot pour area - ils peut regarder les profils et dit 'Oh uh, cette personne aime les mêmes memes, images que moi. On peut être des amis'

Amanda: *Oh oh because I like the idea of creating a socials network in order to find some friends and I believe that people can make some um profiles with the-the- images or even Tiktoks that-that they like and other people in-in the* area - *I do not know the word for* area - *they cans look at the profiles and says 'Oh uh, this person likes the same memes, images as me. We can be some friends'*

Rohan : Mhm

Rohan: *Mhm*

Rick : Ouais um uh il devrait um facile de crier des memes um personnels like uh crier uh des memes pour-pour ouais ouais you got it. Je pense que vous comprenez um

Rick: *Yeah um uh it should um easy to cry some um personal um memes uh some memes for - for yeah* you got it. *I think that you understand um*

At this point in time, the group's exchange had been brought up to a level 7 and then a level 6 by Amanda (ANX+). For Amanda (ANX+), this higher level of interaction led to an increase in heart rate, which is not surprising. However, what was interesting is that this spike in heart rate did not seem to impact Amanda's (ANX+) performance, which counters previous work that has found an increase in anxiety to lead to a breakdown in performance. Indeed, she was able to still express her ideas to her peers quite easily and did not experience much linguistic breakdown. Even when she could not find the word to express a certain "area" of a city in French (*quartier*), she still communicated fluently and without hesitation. Perhaps the fact that Amanda (ANX+) was doing this task in VR allowed her to feel more comfortable and perform better even when experiencing an increase in heart rate. For Rick (ANX-), his heart rate remained low even when he was having trouble expressing himself at the end of this segment. For Rohan (ANX-), his heart rate increased over the course of this interaction, which was surprising considering that he was not contributing to this part of the conversation. Moreover, upon further examining the video footage, Rohan (ANX-) broke “eye contact” with Amanda (ANX+) and Rick (ANX-) as his heart rate increased and started looking around at other parts of the VR setting. Perhaps an explanation for Rohan’s (ANX-) reaction could be that his lack of participation led to an increase in anxiety, as he felt pressure to contribute to the group’s discussion and that breaking eye contact with his group members allowed him to relieve some of the anxiety he was feeling.

The second key moment occurred from minutes 13 to 15 of the conversation. The transcription from this portion of the conversation is given below:

Rick : Oh uh donc uh est-ce que-est-ce que on s'appelle uh ce réseau milieu - uh social pardon	**Rick**: *Oh uh so uh is-is- what do we call itself uh this network middle - uh social pardon*
Rohan : Mhm	**Rohan**: *Mhm*
Amanda : Je ne sais pas	**Amanda**: *I do not know*
Rick : *Laughter* yeah	**Rick**: *Laughter* yeah
Rohan : Oui *laughter* uhh	**Rohan**: *Yes* *laughter* *uhh*
Amanda : Mhm	**Amanda**: *Mhm*
Rohan : Le nom	**Rohan**: *The name*
Rick : Les titres sont difficiles *laughter*	**Rick**: *Titles are difficult* *laughter*
Amanda : Hmm	**Amanda**: *Hmm*
Rohan : Ouais	**Rohan**: *Yeah*
Rick : Hmm	**Rick**: *Hmm*
Amanda : Le nom doit être um catchy quelque chose que les gens peuvent se souviens uh se souvenir oui um	**Amanda**: *The name has to be um* catchy *something that people can remembers uh to remember yes um*
Rohan : Ouais	**Rohan**: *Yeah*
Amanda : Hmm	**Amanda**: *Hmm*
Rick : Hmm	**Rick**: *Hmm*
Rick : C'est difficile *laughter*	**Rick**: *It’s difficult* *laughter*

Rohan : Oui umm	**Rohan**: *Yes umm*
Amanda : Mhm	**Amanda**: *Mhm*
Rick : Umm	**Rick**: *Umm*
Rohan : Il besoin uh populaire avec les jeunes et uh aussi très uh catchy comme Amanda a dit et - c'est uh *referencing the phone ringing in the environment* vous en - entendez le…?	**Rohan**: *It need uh popular with the youth and uh also very uh* catchy *like Amanda said and - it's uh* *referencing the phone ringing in the environment* *you he-hear the...?*
Amanda : Mhm	**Amanda**: *Mhm*
Rick : Yeah yeah *laughter*	**Rick**: Yeah yeah *laughter*
Amanda : *Laughter*	**Amanda**: *Laughter*
Rohan : Yeah	**Rohan**: Yeah
Rick : Ehh *laughter*	**Rick**: Ehh *laughter*
Rohan : *Laughter*	**Rohan**: *Laughter*
Amanda : *Referencing the VR environment* C'est un vrai room	**Amanda**: *Referencing the VR environment* *It's a real* room
Rohan : *Laughter*	**Rohan**: *Laughter*
Amanda : *Laughter*	**Amanda**: *Laughter*

Throughout this part of the conversation, the group was joking with each other about needing to find a name for their social network and also about the realistic sound effects of the VR *Boardroom* environment. This is evident by the amount of laughter occurring throughout their conversation. What is interesting about this moment is that both Amanda (ANX+) and Rick (ANX-) had decreases in anxiety, mostly likely caused by the humor and the light-heartedness of the group's conversation at this time. However, Rohan (ANX-) was the one participant who had an increase (albeit slight) in heart rate throughout this exchange. This was the opposite of what we would expect to see, since the students were not necessarily producing longer discourse or interacting at a higher level. Perhaps Rohan's (ANX-) heart rate increased because he was trying to explain that the title should be catchy or because the phone suddenly rang in the environment and surprised him.

The last key moment occurred from minutes 17 to 19.5 of the conversation. The transcription from this section of the conversation is provided below:

Amanda : Mhm uh je crois qu'avec ça les réseaux sociaux doit être focalisés sur les gens qui l'utilisent parce que um avec maintenant uh beaucoup des gens sont fâchés parce que le - je - je crois que le user interface est pas pour les gens et maintenant c'est pour les compagnies et les gens qui veulent vendre des vêtements et choses comme ça. Et oui donc je crois que pour notre réseaux sociaux, il faut que nous focalisons sur les gens et pas sur les compagnies	**Amanda**: *Mhm uh I believe that with this, the social networks has to be focused on the people who use it because um with Instagram now uh a lot of peoples are angry because the - I - I believe that the* user interface *is not for the people and now it's for the companies and people who want to sell clothes and things like that. And yes so I believe that for our social networks, it is necessary that we focuses on the people and not on companies.*
Rick : Ouais	**Rick**: *Yeah*
Rohan : Ouais	**Rohan**: *Yeah*
Amanda : Mhm	**Amanda**: *Mhm*
Rick : Hmm je pense um uh je pense encore de-de-le - er - du title c'est difficile *laughter*	**Rick**: *Hmm I think um I think still about-about-the er about the title it's difficult* *laughter*
Amanda : Mhm *laughter*	**Amanda**: *Mhm* *laughter*
Rohan : Ouais	**Rohan**: *Yeah*
Rick : Hmm	**Rick**: *Hmm*
Amanda : Je-je crois que *laughter* um on peut juste utilise nos um noms comme Rick, Rohan, Amanda. On peut utiliser R-A-R ou quelque chose comme ça pour maintenant.	**Amanda**: *I-I believe that* *laughter* *um we can just uses our um names like Rick, Rohan, Amanda. We can use R-A-R or something like that for now. We can change*

On peut changer dans l'avenir *laughter* um mais RAR pour maintenant *laughter*	_it in the future_ *laughter* _um but RAR for now_ *laughter*
Rick : *Laughter*	**Rick**: *Laughter*
Rohan : *Laughter*	**Rohan**: *Laughter*
Rick : Hey uh c'est bien uh	**Rick**: Hey _uh it's well uh_
Rohan : Ouais ouais	**Rohan**: _Yeah yeah_
Amanda : Parce que c'est-c'est facile. Je crois que les gens peut um pour se souvenir ça *laughter*	**Amanda**: _Because it's-it's easy. I believe that people cans um in order to remember that_ *laughter*
Rohan : Mhm	**Rohan**: _Mhm_
Rick : Uh c'est-c'est plus er c'est mieux que les titres um qui er que je-je crier *laughter*	**Rick**: _Uh it's-it's more er it's better than the titles um who er that I-I to cry_ *laughter*
Amanda : *Laughter*	**Amanda**: *Laughter*
Rohan : *Laughter*	**Rohan**: *Laughter*
Amanda : D'acc-d'accord pour maintenant nos réseaux sociaux est 'RAR'	**Amanda**: _All-All right for now our social networks is 'RAR'_

Throughout this exchange, Rick's (ANX-) heart rate first decreased and then slightly increased at the end when he was talking. This is what we would expect to see. For Amanda (ANX+), her heart rate was higher at the beginning of the exchange when she was talking about the need to make their social network for people and not companies. However, once the conversation turned back to a name for their social network, her heart rate decreased. Indeed, the conversation had become humoristic again which could have contributed to a decrease in her anxiety as we saw during the second key moment for this task. Interestingly, Rohan's (ANX-) heart rate spiked during this time, which was initially surprising considering the fact that he again was not really contributing to the group's conversation. However, upon further examining the video, this exchange occurred at the same time as the researcher had briefly come in to check on students. Therefore, Rohan's (ANX-) increase in anxiety could have stemmed from the fact that the group was being observed. This echoes what was seen during the first VR task for this group, when Rohan's (ANX-) heart rate also spiked when the researcher briefly came into the VR environment.

RQ5: Participants' Perceptions of the Three Learning Environments

The aim of RQ5 was two-fold: (1) to determine whether a relationship existed between the degree of presence experienced by participants in VR and their self-reported anxiety scores and (2) to examine participants' perceptions of the three learning environments.

Presence and Foreign Language Anxiety

A linear model including participant as a random factor was run to examine the impact of presence on self-reported post-task anxiety scores for the VR tasks. The model output and effect sizes (Cohen's *d*) are reported in Table 24.

Linear Model Output						***Effect Size***	***Conf. Int***	
Fixed Effect	**Estimate**	**SE**	**DF**	**t-value**	**p-value**	**Cohen's d**	**Low.**	**Upp.**
Intercept (PostTask Anx. Score)	28.854	2.749	62.258	10.490	<.001*			
Presence	-.793	.274	56.578	-2.890	.005*	-.768 (M)	-1.390	-.235

Model = lmer(selfreportedanxiety~presence + (1|participant), data = data)
Effect Size: M = medium effect
Table 24. Linear model output for impact of presence on anxiety

Participants' presence scores ranged from 4 to 12 points, which a higher score indicating higher presence while in VR. According to the model, for every increase in one point in presence felt, post-task self-assessed anxiety scores significantly decreased by .793 points [-1.390, -.235] (medium effect), indicating that participants who experienced higher presence while using the VR technology also had lower anxiety during the VR tasks.

Participants' Perceptions

In order to understand how participants perceived the three learning environments and their impact on their language learning and anxiety, two researchers independently coded participants' transcribed interviews using the 9 established codes. The applied codes, as well as the frequency at which they were used and by how many participants overall and in each anxiety group (ANX+, ANX±, and ANX-) are displayed in Table 25.

In order to account for how participants' anxiety profiles related to their perceptions of the three learning environments, participants' comments will be presented and compared according to the three anxiety groups. Moreover, an anxiety continuum (Figure 44), classifying interview participants from most to least anxious will also be used to interpret differences that emerge within each of the three anxiety groups. Lastly, as a relationship between anxiety and presence was determined, a continuum classifying participants according to their ITQ scores will also be triangulated with participants' interviews and anxiety profiles to understand differences in perceptions that emerged (Figure 45).

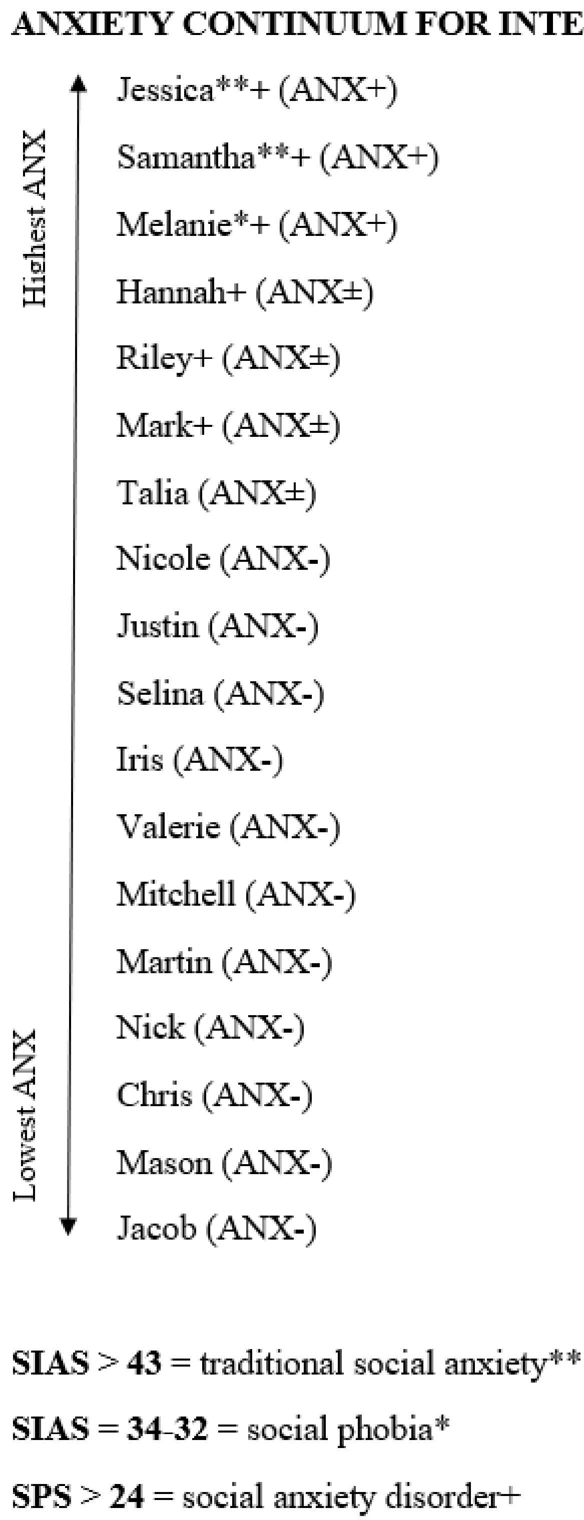


Figure 44. Anxiety continuum for interview data

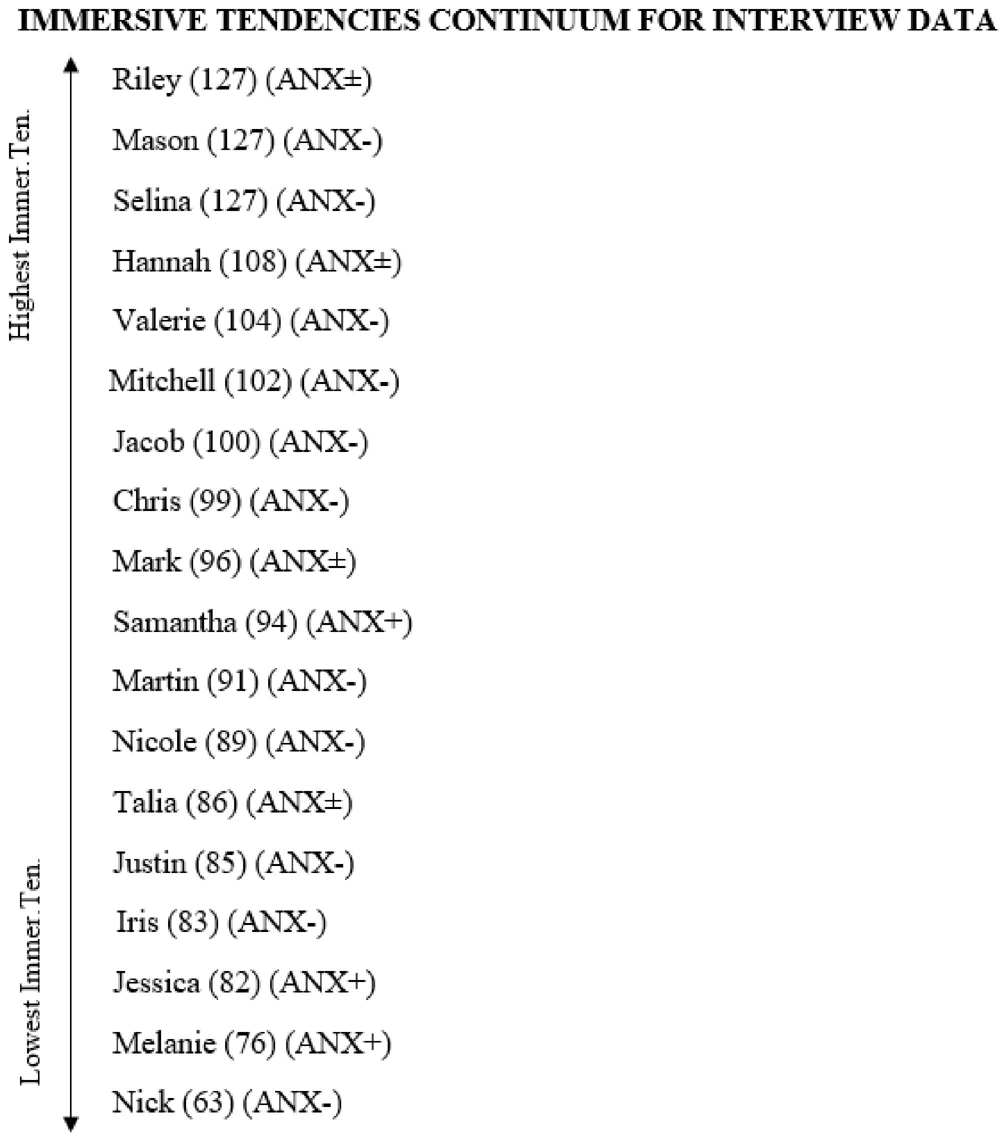


Figure 45. ITQ continuum for interview data

Code	Occurrences (*n* = 805)	No. Participants Mentioning (*n* = 18)		No. ANX+ Occurrences (*n* = 3)		No. ANX± Occurrences (*n* = 4)		No. ANX- Occurrences (*n* = 11)
Mood	156	18	Mood	34	Mood	42	VR Usability	83
VR Immersiveness & Enjoyability	130	18	Perceptions of self/others	31	VR Immers. & Enjoy	33	Mood	80
VR Usability	128	18	VR Immers. & Enjoy	22	VR Usability	32	VR Immers. & Enjoy.	75
Group Dynamics	96	18	Group Dynamics	17	Group Dynamics	31	Perceptions of self/others	54
Perceptions of self/others	96	18	VR Usability	13	Tasks	16	Group Dynamics	48
Zoom	74	17	Classroom	13	Zoom	14	Zoom	48
Classroom	48	14	Zoom	12	Perceptions of self/others	11	Classroom	30
Tasks	45	15	Recording	6	Recording	8	Tasks	24
Recording	32	15	Tasks	5	Classroom	5	Recording	18

Table 25. Frequency of codes applied to interview data

Perceptions of ANX+ Participants

As displayed in Table 25, the most frequently applied code for ANX+ participants was *Mood*, which was used whenever participants mentioned being (un)comfortable, at ease, relaxed, anxious, etc. at any point during the study.

Upon comparing Jessica, Samantha, and Melanie's comments, it was apparent that both Jessica and Samantha benefited from being in a virtual environment -- whether that was VR or *Zoom*. Specifically, Jessica noted that "in person was a little more forced" and "a little bit awkward." Samantha reiterated this sentiment, sharing that she has social anxiety and explaining that:

> I just feel like in person, I feel a little bit more uneasy. I don't know why. I just feel a lot more uneasy in person. Like I always felt a little more discomfort during the in-class sessions just because they're in person and you actually have to talk to people (Samantha, December 1, 2020).

Samantha further explained how she felt more comfortable participating virtually from home and that this benefited her performance, saying:

> I'm also in the comfort of my own room, so I feel like I can - I don't know I just have like this feeling that I can express myself better (Samantha, December 1, 2020).

However, contrary to Jessica and Samantha, Melanie did not enjoy virtual sessions. She explained that:

> I felt more at ease in person [...] because it's more natural and I can understand better than through a screen (Melanie, December 4, 2020)

This preference is not surprising coming from Melanie, as she was the second to lowest participant on the ITQ continuum. Moreover, Melanie was also the least linguistically-capable student in the course and she relied heavily on using gestures to communicate with her peers in French.

The second most frequently applied code for the ANX+ participants was *Perceptions of Self/Others*, which was used when participants referred to body language, eye contact, avatars, or being seen/perceived by others. When examining the participants' comments, it was clear that they were very aware of how much they were being physically seen by their peers across the different environments and how this contributed to their anxiety. Moreover, these participants also commented frequently on body language, and how the presence or absence of it influenced their anxiety. For example, Jessica compared the three learning environments, saying:

> In person it's easier to interpret body language and I think it's a little scary. I guess cause you have to worry more about your whole body instead of just your top half [like on Zoom] or just your voice [like in VR]. In person its more forced eye contact. You sort of have to look at them. [On] Zoom, you have other space to look at and I feel like its normal generally to not stare at the camera. Or like you can stare at them but you're not actually staring at them. That's the same for VR. Like [in] VR you don't have to care about what you look like generally, cause you're just a character. [...] So, like whenever we did the VR things, I generally felt more relaxed I guess and just like - I don't know, I feel like [it was] easier to just talk and not worry too much about any other part of anything else (Jessica, November 17, 2020).

Samantha also noted how although she feels more comfortable on Zoom than in person, the fact that others can still see her on Zoom, compared to VR, does sometimes make her anxious, explaining that:

> With Zoom, I don't have to have my camera on at all times too [...] that's why I like Zoom a lot better [than in person]. Like I know this is going to sound kind of funny, but like when I don't wear makeup [on Zoom] I feel a bit more anxious (Samantha, December 1, 2020).

However, Melanie again had opinions that contradicted those of Jessica and Samantha. For Melanie though, it was less about being seen by others, and more about being able to use gestures to communicate. She compared the ability to use gestures across the three environments, saying:

> I talk with my hands a lot so I think that [being in class] also helps cause you can see other body communication - like non-verbals aside from just speaking. [...] In this VR, I can't - It's like I want to like use my hands and gesture, [but] I also can't do that. So, I feel like part of my communication is cut off. Because I use my hands a lot to get ideas - I'll wave them around. [...] like over *Zoom*, I could still technically gesture and people can see it and I could still read people's faces to an extent somewhat, vs. I mean well in a way, I can't really read people's faces as much in person with the mask [...] but I don't know you could read eyes as well. I guess more in person with the mask vs. over *Zoom* (Melanie, December 4, 2020).

For Melanie, the inability to easily use gestures in the virtual environments, particularly VR, was detrimental to her communicative abilities and ultimately led to her preferring the classroom environment. Again, this is not surprising coming from Melanie, as she relied heavily on gestures to communicate with her peers.

The third most frequent code of ANX+ participants was *VR Immersiveness & Enjoyability*, which was used when participants mentioned finding VR to be immersive or fun and enjoyable. Participants' comments revealed that both Jessica and Samantha found the environment to be very immersive, with Samantha even stating:

> It felt really real because you could move around and as you moved around your environment moved around with you. And that was like super real. And everything was so -- like even though it was obviously very cartoonish, like I I don't know -- just the way things moved and just acted felt really real too. The fact that you could hear the people speaking there too and there was noise, that felt really real (Samantha, December 1, 2020).

As Samantha was placed higher on the ITQ continuum than her ANX+ peers, it is not surprising that she would also comment the most on the immersiveness of the VR environments. However, for Melanie, the environment was "too immersive," to the point where she found it distracting and it made her anxious. She explicitly explains:

> I was kind of confined to this avatar and I'm like -- I can't really move, I'm stuck in one place and then it's almost like sleep paralysis in a way. It's like you're stuck and then you see all these things [in the VR]. I mean definitely there's not the fear that's present but I mean it puts me off that I can't - like it seems so hyper realistic that I'm in this reality but it's almost my brain telling me that I want to interact with it, but I can't. And that's why it was so disorientating (Melanie, December 4, 2020).

Moreover, Melanie also explained that an application where she can physically walk around and not have to be stationary would better enable her to feel more natural in VR. This addresses one of the drawbacks of *vTime XR,* as the principal aim of the application is to sit and discuss with others. It should be noted though that VR applications that require users to “walk around” can often lead to motion sickness and headaches. However, for participants who are less prone to immersive tendencies (i.e., who score lower on the ITQ), this level of interaction might be necessary for them to feel more immersed and comfortable in VR environments.

The fourth frequently applied code for ANX+ participants was *Group Dynamics*, which was used whenever participants talked about their interactions with their group members or the main researcher. Although they were comfortable with their peers, all ANX+ participants reported that the presence of the main researcher, or any teacher in general, contributed to their anxiety. Samantha specifically explained:

> Because I feel like sometimes I would mess up with French and I don’t know - I just feel - it's not just with this class but in other classes too. Sometimes I think ‘Oh I don’t want my professor to think I'm not participating enough or that I'm dumb.’ Or stuff like that. So, I guess that’s why I was more anxious (Samantha, December 1, 2020).

These ANX+ participants’ fear of negative evaluation is a common apprehension of those who experience FLA. Indeed, one of the most cited causes of anxiety by language learning students is that they fear being negatively perceived or evaluated by those around them (Aslan & Sahin, 2020; Boudreau et al., 2020; Dewaele & Dewaele, 2017; Fondo et al., 2018; Ipek, 2016; Khoroshilova, 2016; Maria-Signona & Barros-Del Rio, 2016; Shirvan & Talebzadeh, 2020; Vo et al., 2017; Zheng & Cheng, 2018).

The next three most applied codes for these participants were *VR Usability*, *Classroom*, and *Zoom*. *VR Usability* was used when participants talked about how easy or hard it was to use the VR technology and *Classroom* and *Zoom* were used when participants mentioned anything about the respective environments that did not fall into the *Mood* category. The data from these three codes help to give an understanding of how participants felt navigating the various learning environments.

All ANX+ participants noted that they found the VR easy to use and navigate. It seems that giving students their own VR headset to use from home alleviated some of the technological challenges that students faced during the pilot study when using VR on campus. The students also did not report any negative physical side effects (e.g., headaches, nausea, etc.) from using VR.

Regarding *Zoom*, it appears that the on-going COVID-19 pandemic that surrounded this study influenced ANX+ participants' perceptions of using *Zoom* for language learning. All participants noted that they have become accustomed to learning on *Zoom* and are consequently comfortable with it and find it easy to navigate. For example, Jessica (November 17, 2020) specifically noted, "I think definitely after last semester - having the end of the semester being on Zoom, it's sort of helped me to acclimate to more *Zoom* style interactions." Melanie (December 4, 2020) expressed similar sentiments. However, she did note that *Zoom* has "limitations" and that for her it is still not "up to par obviously to the natural in-class environment." Moreover, Samantha noted one of the many affordances she liked about *Zoom* compared to VR and the classroom, explaining that *Zoom* helps her to look up vocabulary in French:

> When its virtual, I feel like I have also access to the internet. I type really fast too, so I can Word Reference something really fast and the internet isn't slow.

> Sometimes when I'm in class - I'm on Word Reference sometimes [and] it takes a little bit longer (Samantha, December 1, 2020).

Concerning the traditional classroom, the ANX+ participants noted several limitations aside from just the added anxiety that comes from having to interact with other language learners face-to-face. Samantha (December 1, 2020) noted that in person learning is often distracting for her, as "there's a lot of people" and she "get[s] super distracted by the noise." Both Jessica and Melanie pointed out the difficulties of successfully communicating with other students in class with COVID-19 protocols (e.g., masks, social distancing) in place. Specifically, Jessica explained:

> Sometimes the masks were a little intimidating too - just trying to talk over those [...] Cause if you don't know what you were saying and no one could understand you, it's kind of just frustrating. And then you're, kind of, just like, you know, 'Never mind I'll stop talking' (Jessica, November 17, 2020).

Indeed, for these students, the health measures put in place to protect students from COVID-19 seem to have exacerbated the anxiety that already accompanies conversing in a foreign language.

Lastly, the least frequently applied two codes for ANX+ participants were *Recording*, which was used whenever participants mentioned being recorded, and *Tasks*, which was applied when participants talked about the tasks themselves and whether they impacted their anxiety and/or performance. None of these participants reported that the task structure or topics contributed to their anxiety or impacted their performance during the sessions. Only one participant, Jessica, commented on the fact that their group interactions were recorded. She particularly found that being recorded was stressful in the classroom setting -- compared to on *Zoom* or in VR -- explaining that:

> The camera was sort of - not in our face but like you can physically see it and then the microphones are pretty like - the wires and stuff - it's not triggering but it's a sign [..] I was like 'Oh there's a camera, there's a microphone.' And I was like 'Maybe I don't want to speak too loud because I don't want them to pick me up too much' and stuff like that (Jessica, November 17, 2020).

It is not surprising that out of the ANX+ participants, Jessica would be bothered the most by being recorded, as she is the highest participant on the anxiety continuum and has talked extensively about how being seen by others increases her anxiety.

Perceptions of ANX± Participants

Similarly to ANX+ participants, the most frequently applied code for ANX± participants was *Mood*. However, whereas ANX+ participants primarily talked about how being face-to-face made them uncomfortable and anxious, ANX± participants mentioned more how the VR environment contributed to them being comfortable. For example, Talia (April 23, 2021) noted that although she is "pretty at ease all the time in French" she did "appreciate going to the gardens and hearing the sounds." Hannah, who was the third highest on the ITQ continuum, also compared VR to a video game, saying that:

> It felt less like an intense nerve-wracking environment I think. Cause it did feel more like a game, you know, something maybe closely related to video games. [...] If anything I think it made it feel more casual, more relaxed. Maybe less like a formal classroom setting (Hannah, April 23, 2021).

One participant though, Riley, explained that she found VR to be stressful, primarily because she was not able to look up words within the VR platform. She explained:

> So, I think that was what I was most anxious for, was having no aid and having to just speak. I think the one that made me the most anxious was the day we did VR. [...] because I'd forget a word and panic, and then I'd be like oh my gosh. And it's not even a matter of like I'm not getting out what I want to say. I'm worried that my classmates aren't going to understand what I'm trying to say. And I don't want to hinder the conversation because of that, so I think that was when I would have the most anxiety from it (Riley, April 30, 2021).

For Riley, the inability to look up words in VR was seen as a drawback and contributed to her anxiety. This echoes previous research that has found learners to complain about this feature of virtual spaces (Mroz, 2012). However, it should be noted that VR's ability to simulate the real world where learners must navigate a conversation with the linguistic knowledge they have is one of the exact reasons why VR could be considered a valuable educational tool.

The second most applied code for ANX± participants was *VR Immersiveness & Enjoyability*. Upon comparing the participants' responses, all participants commented on how the detailed VR settings contributed to their experience. Specifically, Riley, who was highest on the ITQ continuum, found that the VR settings enhanced the speaking tasks that students were doing. She explained that they would help her think of ideas to contribute to the conversation:

> I felt like it [VR] did add to it [the tasks]. I would, even when we were talking about sustainability and stuff like that. I looked at the water and was like 'Oh, water!' It helped me in thinking of ideas (Riley, April 30, 2021).

Talia and Mark specifically commented on how the environments added to the experience by changing up the monotony of constantly being at home and taking courses on *Zoom* during the pandemic. Specifically, Talia explained:

> It was nice because of being at home or wherever because it was like the pandemic. But I just kind of liked how we had different locations in the VR headset, so it felt like something new every time we did it in a way (Talia, April 23, 2021).

Mark echoed this sentiment, adding that he often would get distracted working from home on *Zoom* and explaining how VR helped to reduce some of these distractions:

> Being in VR removes the distractions of working from home. There's just things happening outside the window. There's just stuff and for me it's much more difficult to concentrate at home than it is in most other places. Just because there's so much stuff going on. And with VR, it's just a very controlled, very sanitized environment if you will (Mark, April 27, 2021).

Indeed, it seems as if VR's ability to remove the outside world and immerse students in a full 360º environment allowed them to better focus than on *Zoom* calls that only afford partial immersion via a computer screen.

The third most frequently applied code for ANX± participants was *VR Usability*. Talia, Mark, and Hannah specifically reported that they found the VR easy to use and that they were comfortable doing so. However, Riley experienced technical difficulties that made it difficult for her to communicate with her classmates. She recounts her experience, saying:

> Sometimes we'd be in a room and the sounds around me would be too loud, so I'd have to, while my classmates were talking, go in and turn down the sounds of the room [VR environment]. And then, all of a sudden, my left hearing part of the headphone, like the speaker, would go out, so I'd have to turn my head to hear everyone sitting over [t]here (Riley, April 30, 2021).

She goes on to explain that these technological challenges ultimately led her to prefer the *Zoom* sessions, as they felt "more organized" and "more controllable." Hannah also noted how while she felt that VR was easy to use, it can also be a bit unpredictable. Specifically, she talked about a moment in VR when her and her groupmates encountered a random user and had to figure out how to get rid of them.

> Yeah there was this one moment where - You know how other people can join? We had it on lock so they had to request, but the person who joined just so happened to have the same name as someone else in the class, and I can't remember who that was now, but it was just someone who like wasn't in our group. And I let them in cause I thought maybe their group wasn't there or something and it was weird. I don't know, but they didn't say anything, and we couldn't figure how to get them out, but their character was like doing all these weird hand movements and stuff, and it was just kind of creepy, like I didn't know who this stranger was in the game but that honestly was it, we figured out how to get them out and then everything was fine (Hannah, April 23, 2021).

Riley's comments reflect some of the difficulties that accompany using VR for educational purposes. As VR for the general public is still fairly new, technological challenges are to be expected even when students are trained to use the technology. Moreover, while *vTime XR* is a more private VR social network than others, these types of chance encounters can still occur and cause students difficulties on open VR platforms.

The fourth most frequently applied code for ANX± participants was *Group Dynamics*. As with ANX+ participants, both Hannah and Riley noted that the presence of the main researcher would contribute to their anxiety. Hannah specifically explained:

> Yeah I feel, and this is, like again not just with you. It's any instructor. I always kind of have a little heart jump moment, like 'Oh my god. I really need to do well now.' Like even though I know that you're just there to watch for improvement, there's still like, I think it's just the idea of having a teacher watching where you know, you get in your head and just. Again, it goes back to overthinking, and trying to not make any mistakes, like trying to be perfect (Hannah, April 23, 2021).

However, for Riley, the anxiety stemming from the presence of the main researcher lessened over time. She stated:

> It [the presence of the researcher] did [bother her] at first. Just because I would get anxious when *Teaching Assistant* would pop in break out rooms, or when any teacher would. But then I was like 'Okay no, she's just observing. It's not that big of a deal. Just keep going.' And so, I think by the end of it, it didn't stress me out anymore. At the beginning it did but not in an extreme amount it was just a little bit of like 'Ope! She's in the room now' (Riley, April 30, 2021).

It is not surprising that Hannah and Riley were the two ANX± participants who found the presence of the main researcher to be stressful. These two participants were the highest on the anxiety continuum within the ANX±, and thus their profiles aligned more closely with those of ANX+ participants, who consistently found the presence of the research assistant -- who they perceived as a teacher -- to contribute to their anxiety during sessions.

Like ANX+ participants, ANX± students did not find the presence of their peers to be stressful during the sessions. All participants reported that they were comfortable interacting with their peers, and that they felt they were able to have productive, conducive conversations.

Only one participant, Mark, noted that he was not stressed by one of his group members, but annoyed at their lack of preparedness. He specifically explained:

> One of the hesitancies I had about the VR, and I think just in my group, was the fact that a particular member of our group always had problems [...] So that was distracting at times, but to be fair, he also had problems on *Zoom*, so it wasn't really necessarily related to VR. [...] It would have been nice if *Group Member* was a little more reliable. [...] It was nice when he actually called in from somewhere that wasn't his car (Mark, April 27, 2021).

Mark unfortunately expressed one of the issues that would set groups back occasionally when it came to starting the tasks. Indeed, students would sometimes come to class unprepared (e.g., had not charged their VR headset, arriving late) which would then lead to frustration for their group members.

For ANX± participants, the fifth most applied code was *Tasks*. Similarly to ANX+ participants, none of the ANX± participants found that the tasks contributed to or lessened their anxiety. In fact, Riley even mentioned how that she found the format of the tasks, particularly the role-playing aspect, to be particularly helpful when guiding her group conversations. She explained:

> I did enjoy the roles because it was nice to have a guide of what to speak about. Cause I think if I didn't have those roles, or I didn't have an idea of what to respond with, the three of us would be a little overwhelmed and would be like 'Oh, well who wants to speak on this now?' [...] The role helped me guide what I was going to say (Riley, April 30, 2021)

Riley's thoughts echo previous research that has found that role playing activities encourage students to actively participate in conversations (Deutschmann et al., 2009).

The sixth most frequent code among ANX± participants was *Zoom.* These participants echoed sentiments of ANX+ participants, saying that they have adjusted to *Zoom* since the pandemic forced their classes to move online. Like Samantha (ANX+), Riley (April 30, 2021) also pointed out that an advantage of *Zoom* was being able to easily look up words in French while completing activities, saying that she liked how she is able to "quickly look up a word on Word Reference and keep going." Riley (April 30, 2021) also discussed how she liked the convenience of fitting *Zoom* courses into her schedule, saying that "it is kind of convenient to not have to worry about traveling to the other side of campus to go to class." However, contrary to ANX+ participants, ANX± mentioned the negatives of *Zoom*, not pertaining to anxiety, but simply to the aspects of *Zoom* fatigue. Talia (April 23, 2021) specifically said that she's "made do with it [*Zoom*]" and Mark (April 27, 2021) explained that "you know, sitting in a little room all day long on *Zoom*, it's really isolating."

The code *Perceptions of Self / Others* was the third least commonly applied code to ANX± participants. Unlike ANX+ participants, ANX± participants talked less about being seen by others and more about how the avatars added to their experience in VR, with Talia explicitly saying:

> I liked it because at least, for the most part, they [her group members] customized their avatars to look like themselves. So, I felt like it was better to see that rather than just hearing their voices and staring into space. So, I thought it was a nice addition. Especially cause their hands and mouths moved when they did so it felt more human if that makes sense (Talia, April 23, 2021).

One participant, Hannah, did note that being shielded by an avatar and not being seen by her peers led to her feeling more comfortable in VR, saying that:

> When I get anxious, my face gets red a little bit. And I just know, like in class, you know in front of people, when my face gets red, then I get even more anxious, you know? So that's something. When they actually can't see me, I feel a little more comfortable. [...] Maybe that goes back to again like not being able to see me, but probably when we were in groups in the VR, I felt like more comfortable. It's just the same thing. That like they couldn't see me, so I felt a little less awkward in a way I guess (Hannah, April 23, 2021).

Again, it is not surprisingly that Hannah's feelings about being represented by an avatar within VR align with those of ANX+ participants, as she was the highest ANX± participant on the anxiety continuum.

The last two least commonly applied codes for ANX± participants were *Recording* followed by *Classroom*. For all participants, aside from Hannah, being recorded during the study sessions did not contribute to anxiety. Talia and Riley explicitly explained that they were comfortable being recorded, because they knew that it was simply for research purposes. However, Hannah did not like the fact that everything she was doing would later be watched, stating:

> I knew that like everything I said was going to be monitored at least a little bit later. I think it made me nervous. A little bit less because there wasn't someone watching me in the moment, but it was also kind of in the back of my mind (Hannah, April 23, 2021).

Regarding the *Classroom* code, no ANX± participants who partook in the optional interview completed classroom tasks, as they were all enrolled in the course during the Spring 2021 semester when it was taught entirely online and remotely. Therefore, they did not comment much on classroom learning, aside to compare their experiences generally to previous in-person French courses.

Perceptions of ANX- Participants

Contrary to ANX+ and ANX± participants, the most frequently applied code for ANX- participants was *VR Usability*, not *Mood.* All eleven participants reported that they found VR easy to use and that they did not experience any negative side effects (e.g., nausea, headaches). Chris even noted how surprised he was by how natural the VR environments felt, saying that:

> I think I was surprised at how natural and normal the VR felt. Like when I first saw it and we were trying it on in class and stuff on the first day I was like, this is going to be weird. Right? Like sitting in my room and having no idea who I'm talking to or what's going on (Chris, November 19, 2021).

However, Mitchell and Nicole both commented on how they felt the VR set up was a bit too time consuming, especially Mitchell who was only able to use VR ultimately for one session in Spring 2021 (as opposed to three) due to being absent. He specifically explained:

> I mean figuring out how to set everything up, I feel like it took us like two classes, which definitely, I don't know. I feel like maybe if there was, maybe one time where it was like a longer chunk where you like learned how to use it, instead of having to do that during class time or something. But I feel like the preparation wasn't worth the payoff necessarily because we only used it once (Mitchell, April 26, 2021).

For Nicole, the difficulty stemmed more from the setup that students had to go through during each VR session. She found that using VR was an extra step to get into class, as opposed to just logging onto *Zoom*. She noted:

> When I mention the setup, it's just that we would get into the *Zoom*, make sure everyone is in the *Zoom*, then try to get on VR. The wording that I said, 'takes longer than necessary', it's not like there's some ways that it could have been shorter that I can think of tangibly. It's just that the setup had to take a long time. It was like, 'Okay we've gotta put a lot of effort into getting everything together before we can get into the class' (Nicole, April 27, 2021).

The length of setup was of course exacerbated at times by students who would forget to charge their VR headsets or to prepare properly for class. This is something that needs to be considered moving forward, as even sending frequent reminders did not seem to help some students to remember to come to class prepared. Mason highlighted a problem that was common among some students:

> I mean VR sometimes it's a little finicky to get everything set up. In case you forget to charge it - It can be a problem. Cause I did that once. I forgot to charge it, and I had to wait a couple minutes to actually start the class. But like, with my laptop, or I could literally use a phone, iPad, or whatever, or even like a friend's device. But if your headset breaks, or somethings wrong, it's just a lot more, you could lose a lot more points, if that makes sense, in class. Or just, you could miss some time (Mason, April 30, 2021).

In terms of the *vTime XR* platform itself, Selina pointed out how certain aspects of it led to technological difficulties. She stated:

> The vTime platform was a bit confusing when - for like connecting with people. At the moment of like 'Oh I'm looking for this person. I'm sending them a request but they're[...]' It was just a bit confusing. Like in the end it was not too hard to get to the other people but like it felt like every time we met, I think for me it was only twice or three times, it took us a moment to figure out how to join them (Selina, December 2, 2021).

The second most applied code for ANX- participants was *Mood.* Although all ANX-participants reported that they typically feel at ease in their foreign language classes and do not experience anxiety when it comes to speaking French, there were a few factors that either contributed to them feeling more relaxed or stressed during the consensus-building activities. For Jacob, Mitchell, Martin and Nicole, the VR environments put them more at ease, specifically the 'Japan House' environment. Jacob (April 27, 2021) specifically explained that the "Japan House music made me [him] feel relaxed" and Mitchell (April 26, 2021) commented that "just seeing the [VR] scenes" made him feel particularly "calm". Nicole (April 27, 2021) also noted that she "felt more at ease when we were [she was] in a less monotonous environment and experienc[ing] all the over-the-top locations." Martin noted that VR helped cut out distractions that would increase his anxiety, saying:

> Whenever we were doing the VR it just cut out a lot of the distractions that weren't part of the VR atmosphere, so, I think that that really helped cause like doing it on *Zoom,* I'm just like seeing a bunch of other things on my screen right now and then in person it's easy to look away or do something on your phone. So, when you're doing the VR thing, that really helped because I couldn't do anything

> else. So, it really helped just cut all that way so that I couldn't really think about that right now, and I could just focus on the French (Martin, November 30, 2021).

However, for Selina, VR both put her at ease and increased her stress. She explained that being able to converse from the comfort of her own home in the peaceful environments was relaxing, but that not being able to see her group members made her insecure about dominating the conversation. She specifically said:

> And I feel precisely because of this factor of like not knowing whether people want to talk [due to not seeing them], it felt very uncomfortable to me sometimes when doing the VR because like I wasn't hearing anybody talking sometimes and like I just felt in the need of like monitoring the conversation or like guiding the conversation sometimes and at the same time feeling insecure about 'Oh should I actually be guiding this so much or do these people actually want to say something but I just can't tell? (Selina, December 2, 2021).

Selina's reaction is not surprising, as she is a language teacher herself and often felt the need to ensure that her group was on task and constantly speaking French.

Furthermore, Mason and Nicole said that the tasks themselves, and their particular roles within them, led to them feeling more relaxed. Mason specifically commented on the hierarchical nature of the roles and how he felt more relaxed when he was either in a higher or equal position with his peers :

> There were some that I was more relaxed with the role I had. Like some people had the director, the boss. So those were ones I was comfortable with cause like from the introduction, it seemed like I was supposed to just listen to the ideas that the people beneath me had per say, you know what I mean? And then I just had to

> say, ‘Oh that’s a good idea.” Or, “I like this”, and just continue to ask questions. So, like those roles. Or the ones where we were on equal playing fields, where everyone had to speak the same amount. Those were easy. But like I never felt like stressed out or I never felt like my French level was too low at any point (Mason, April 30, 2021).

Nicole also talked about how she felt more comfortable when the role she was playing lent itself the opportunity to be silly, saying:

> When there’s any kind of charm involved, and ability to be silly with it, is when it felt the most -- not that the other ones were uncomfortable -- but felt the most comfortable. It was just like, ‘Hahaha!’ You know? You’re all in the same boat. You’re all in the same boat of just goofing around and trying to communicate in French and can make mistakes (Nicole, April 27, 2021).

Nicole’s sentiment reiterates findings from previous research that have found role playing to contribute to lower anxiety (Boudreau et al., 2020; Dewaele & Dewaele, 2017).

However, for ANX- participants, there were a few factors that contributed to them feeling less comfortable, notably interactions with their peers or being reminded of the on-going COVID-19 pandemic. For Iris, Mitchell, Mason, Martin, Justin, and Valerie, the ability to successfully exchange ideas with their peers impacted how they felt during the tasks themselves. Specifically, Iris noted that she was most relaxed when she was able to successfully collaborate with her partner, citing a task where she felt they did particularly well:

> So, another VR session actually - I think we were talking - I think it was like ‘You’re cutting the budget for a school.’ I remember like the location we chose to stay in was near the beach. So, I think I did remember feeling a little bit more

> relaxed at that moment. Yeah more at ease I'd say. And plus, I feel like the ideas we were coming up with were better in that situation. Like, it was a little easier I guess to collaborate with my partner (Iris, December 9, 2020).

For Mason, Martin, and Mitchell, they found that their interactions were a bit awkward when they were missing a group member and only left to interact with one other person. For example, Mason (April 30, 2021) noted that sometimes neither person had "anything else left to say [...] so it was just a little bit awkward." Mitchell echoed this sentiment, saying that:

> But another time that was a little bit uncomfortable was when it was just me and another person, like when the third member of our group was absent. It was just us two. There was a little like awkward silence (Mitchell, April 26, 2021).

Lastly, for one ANX- participant, Nick, any reminder of the COVID-19 pandemic led to anxiety, whether that was conversation topics, COVID-19 protocols, or using *Zoom*. When asked whether he noticed any changes in his anxiety across activities, he replied:

> All-in-all it kind of just boiled down to reminders of the current state of the world. Like that just really stressed me out a lot (Nick, December 10, 2020).

The third most frequently applied code for ANX- participants was *VR Immersiveness and Enjoyability*. For these participants, VR was a source of enjoyment and excitement. Particularly, ANX- participants mentioned that the environments were game-like and exciting, that VR broke up the monotony of Zoom, and that VR contributed to the overall experience of completing the task by making it more realistic and more similar to in-person communication. When comparing VR to a game, Nick specifically noted that:

> I really enjoyed VR because there was sort of a sense of like 'Oooo, ahh!' like everywhere you look around. It was like 'oh, this is fun!' Like it felt

> sort of like a game almost (Nick, December 10, 2020).

Nicole and Mason also echoed the idea of the VR environments being exciting, saying:

> It was more being excited when we were in VR and looking around it was like 'Woah!' Seeing the new environment together was like, 'Ha ha, funny things going around!' (Nicole, April 27, 2021)
>
> It just felt a lot more interactive in general. Like having to put that thing [VR headset] on, and then choosing a different location each time was pretty cool. (Mason, April 30, 2021)

As with ANX± participants, the ANX- participants found VR to provide a nice change from the monotony of their daily *Zoom* calls. For example, Mason (April 30, 2021) explained that he enjoyed learning with VR, since he wasn't "just sitting and looking at a *Zoom* lecture like I've [he's] been doing for the past year and a half." Iris further explained how she found VR to provide a sense of escape from her typical routine on *Zoom*, saying:

> You know, being in a different setting, I did get a chance to like escape from my usual bedroom, so I'd say that that's really what made it most interesting (Iris, December 9, 2020).

Finally, ANX- participants found that VR contributed to their overall experience, either by providing a realistic setting in which they could exchange their ideas or by making their interactions more realistic than on *Zoom*. For example, Nicole specifically commented on how VR provided an authentic context that enabled her group to have further discussions in French:

> I like how instead of the context in which we're having discussions, you know, being the *Zoom* call -- Where, what's there to talk about but the task? It's just the idea of having conversations about what's going on. I mean it's funny when

> you're in any specific VR setting and there's something going around, like 'Oh woah, what's that?' You know? Because the settings were a little over the top -- most of them. Like when we would be in 'the Boardroom', there would be a freakin' helicopter going around and landing. Like that was just something to point out and laugh at. And even if you were being a little off topic, we were talking about the setting in French, like what was going on in the setting (Nicole, April 27, 2021).

When comparing VR and *Zoom* to face-to-face interactions, Jacob and Mitchell commented on how VR resembles in-person interactions more than *Zoom* does, particularly because students cannot mute or turn their camera off in VR but are forced to converse back and forth as they would in real-life. Jacob specifically said:

> I think I talked more in the VR sessions. Because in *Zoom* we're so used to just turning off the camera and muting ourselves. For VR, it would be a little awkward to not talk because we're all in the [virtual] room (Jacob, April 27, 2021).

Mitchell echoed this sentiment, explaining that :

> The VR stuff was cool and I felt like it did improve like how immersed I was. I mean, it felt like I was in the same room with someone talking to them. [...] Definitely it was better than on *Zoom* in terms of having conversations because there's not a mute button. You can't mute yourself. And then someone talks and says 'Oh no, you go you go, I'll get back on mute.' Which I think definitely helps in terms of the conversational side (Mitchell, April 26, 2021).

Martin reiterated this idea, saying that VR felt more realistic and less disconnected than a typical *Zoom* call. He explained:

> Well, I just think that, obviously classroom setting is probably the best opportunity to do a French speaking atmosphere, and I thought the VR was much closer to being in that classroom atmosphere than just being on Zoom because, I don't know, it just felt like it was more like talking to other people. It wasn't as disconnected as you are when you're on the screen (Martin, November 30, 2021).

Indeed, for ANX- participants, VR's ability to simulate a real back and forth conversation led to students feeling that they spoke more and had more natural conversations. Moreover, it is important to note that although the VR environment might have been cartoonish, it felt more realistic to students than physically seeing each other on *Zoom* in terms of the quality of interactions it afforded.

The fourth most frequently used code for ANX- participants was *Perceptions of Self / Others*. Like ANX± participants, ANX- participants commented on the use of avatars in VR and how they perceived them as just extensions of their peers. For example, Nick explained that:

> Their avatars (his group members) were all like pretty similar to them and I never actually took notice to the fact that we were in avatars. Cause I was just like 'Oh, we're just talking to each other.' Like they're being represented by something even if it's not actually them. It's something to talk to and interact with (Nick, December 10, 2020).

Nicole (April 27, 2021) echoed this sentiment, explaining that she got "used enough to my [her] group's avatars that I [she] could see them as second versions of my [her] peers even though they never really looked like them."

One participant, Iris, noted that she did feel less perceived due to being shielded behind an avatar in VR, but added that this did not necessarily influence her level of anxiety. For her, it was more about removing the sense of self-perception that can often accompany seeing oneself on *Zoom* calls. She explained:

> I mean [be]cause you know on *Zoom*, you see yourself. So, I did get a chance to not focus on how I looked [in VR], you know? Instead, I was really just looking around, looking at the other avatar. So yeah I would say being in VR - It did I would say remove that sense of self-perception (Iris, December 9, 2020).

Mason (April 30, 2021) also talked about being able to see others, saying that he found it "really awesome" that he was able to perform gestures and maintain eye contact with his peers via his avatar. He noted that VR's realistic headtracking made him "want to actually look at the person [his peers]" and recounted that "all of us [him and his groupmates] tried to maintain some sort of eye contact."

However, for Justin, Selina, and Violet, being unable to see their peers directly took away from the experience. Justin and Violet specifically explained:

> I'm someone who likes connection more, I like to see the person, and in-person I can see their body language, or I can hear their tone, and I know I can do the same over *Zoom*. As of right now, it's hard to do that over VR since I can't really see the person. I just think, in regard to having like actual conversational dialogue, over a digital platform, the human element is missing (Justin, November 19, 2021).

> [In the classroom] yes, because you can usually play off of people's reaction expressions, because that's half of the communication is in reaction, it's not just speaking and reacting with appropriate responses. If maybe there's skepticism in the eyes, especially with masks or something, you can react and take the turn of

> the conversation that way because it's not just regarding the topic it's about how the person is actually speaking and the persona behind what they're trying to convey which makes it a lot easier because in VR you obviously can't do that (Violet, November 19, 2021).

For Selina, she felt that being unable to see her groupmates negatively impacted the conversations themselves, saying that:

> I felt like the conversations on the VR were slower. Like, they - I don't know, sometimes, because I didn't know if someone was like trying to talk, you know like when you talk to someone and you can see their faces that they're like 'I want to say something' you cannot really tell on the VR because of course the characters don't change their facial expressions, but you could see that in *Zoom*. You can tell that someone wants to say something (Selina, December 2, 2021).

These comments made by ANX- participants are particularly interesting, as many ANX+ participants cited VR's ability to visually shield them from others as a contributing factor to their lower anxiety.

The fifth most frequently applied code for ANX- participants was *Group Dynamics*. All participants, aside from Iris, said that they found working with their group members to be comfortable and enjoyable. It should also be noted that, compared to ANX+ and ANX± participants, no ANX- reported being stressed by the presence of the main researcher.

For Iris, she found communicating with her partner to be particularly difficult and frustrating, notably because of her partners limited linguistic abilities in French. She discussed the difficulties when reflecting on their sessions together:

> It's just the partner I had I think made it a little bit harder cause I felt like I didn't get a lot of chances to speak actually. I don't wanna like – sneak diss or anything. I'm just saying, I felt like a lot of time was spend [on] my partner trying to get through her sentences, and I didn't really get a chance to really express myself. [...] I mean yeah I was comfortable with her. I was cool with her. But I think that it didn't really help me that I was partnered with her. I felt like if I was with someone who spoke it [French] more fluently, we could have probably discussed more things. And I would have [had] more practice to have been able to like, you know, build a rapport. Instead of it being like 'Okay they're fumbling through their sentence' and I'm just sitting here like 'Hmm K. I mean I have some ideas, but I'm waiting for you to get through what you're trying to say' (Iris, December 9, 2020).

Indeed, it should be noted that Iris was partnered with Melanie throughout the semester, who had lower linguistic abilities and did rely heavily on gestures to communicate. Unfortunately, the fact that it would take Melanie much longer to communicate her thoughts was frustrating for Iris, who would spend most of the tasks waiting on Melanie to finish speaking.

The sixth most commonly used code for ANX- participants was *Zoom*. Upon comparing participants' responses, eight out of eleven mentioned that they had experienced some form of *Zoom* fatigue, specifically saying that they found *Zoom* classes to be "exhausting" (Iris, December 9, 2020) and "monotonous" (Nicole, April 27, 2021). Several also noted that they felt that they were not learning and retaining as much information on *Zoom* and that they found *Zoom* to negatively impact their peer-to-peer interactions. When discussing how *Zoom* has impacted his learning, Mitchell explained:

> If I'm being honest, I don't feel like I'm retaining information at all in pretty much all my classes. Which is kind of sad to say. I'm kind of worried about the future and what classes I'm going to need to look back on information from. I'm just going to not know. I feel like now I'm not learning. I'm just studying for the next test, or exam, or piece of homework, instead of actually learning. And I mean some of my classes the teachers just so bad. [...] I'm just like going on YouTube and trying to learn the material and stuff, and like reading the textbook too (Mitchell, April 26, 2021).

Several students also found that their peer interactions were negatively impacted by *Zoom*, mostly due to the fact that students can turn their microphones and cameras completely off. Nick specifically said:

> It's like the student-to-student interactions aren't there as much. Cause most of the time, students just have their mics off and if we talk to each other we talk in the chat. And if we're not like interacting-interacting, I feel like we don't really get that sort of communication and for me that's really important. When I'm like learning a new subject, I talk about it and that's how I get it cemented in my mind. So, I haven't really done too well with the Zoom lessons (Nick, December 10, 2020).

It should be noted that Nick (December 10, 2020) despised Zoom sessions so much, even concluding his interview by saying "Je déteste Zoom (*I hate Zoom)*," that he purposefully avoided attending any of the Zoom sessions in the current study. For similar reasons, Mitchell also directly critiqued the use of *Zoom* for learning languages. He explained:

> I definitely feel like learning French online [is] virtually impossible. That's just my opinion. I feel like it'd be really hard to miss out on that conversational -- you can't replicate a conversation in *Zoom* in my opinion. It's just not possible (Mitchell, April 26, 2021).

Interestingly though, Violet who was enrolled in the Fall 2021 course noted that she had adjusted to *Zoom* over time. She specifically explained:

> [Be]cause we were able to adapt in terms of social skills. I feel like at first *Zoom* burnout was a big thing, and I'm sure it still is, but we're more accustomed to socializing via a two dimensions representation of a three dimensional being so we don't have to worry so much about what I was talking about earlier, your place in the space, and the energy between two people in a physical space because now we have a computer. At first it would have been more difficult for me, but now it just seems natural (Violet, November 19, 2021).

It should be noted though that Violet's French course was taught in-person, aside from the consensus-building activities that were specifically designated for *Zoom*. Perhaps this led to her viewing Zoom more positively than participants from previous semesters (Fall 2020 and Spring 2021) who spent much more course time using the platform.

Finally, the three least frequently used codes for ANX- participants were *Classroom, Tasks,* and *Recording*. Aside from finding the classroom environment to be more natural, several ANX- participants discussed how the COVID-19 pandemic had altered their perceptions of in-person learning, making them appreciate it more. Chris (November 19, 2021) specifically noted: "I think probably I've always thought and liked in person learning more, but I think probably the pandemic has made me appreciate it more to be honest." Justin (November 19, 2021) echoed this sentiment, saying that "In regard to learning a foreign language, I would say that COVID-19 has made me appreciate the in-person element of learning."

Concerning *Tasks*, all participants, aside from Nick, reported that they were comfortable with the task topics and that they did not find that they influenced their performance or anxiety. Interestingly, although only one of the task topics (the Olympic Games) specifically addressed COVID-19, Nick (December 10, 2020) noted that any subject matter that "would specifically involve talking about COVID-19 or about solutions to COVID-19" would send him into a "downward spiral." Specifically, Nick found the education themed task to be the most stressful. It seems that although COVID-19 was never directly incorporated into this task topic, the presence of the on-going pandemic was ever-present in Nick's mind and caused him to automatically relate the topic to the health crisis. It is true that Nick's group related almost all of their tasks (e.g., education, technology) back to COVID-19 despite not being necessarily instructed to do so.

Regarding being recorded, all participants reported that they were comfortable with it. Mitchell even found that it was beneficial in that it encouraged his group to refrain from using English during tasks. He explained:

> The recording, you know normally, in a French class, you mostly speak French, but there's the little, 'Oh what does this say?', 'Oh this is saying...'. Like you translate it, and then you answer in French, but you sort of do that in English. So, in normal 205, whenever we're given questions in a breakout room, I'll be like 'Oh what does that do?' And then we'll try and figure out as a group like what it means in English and then answer in French. But getting the questions in French, and being recorded, you can't do that. So, we'd have to come up with everything

> on the spot. Which I actually liked because it threw me back to when I was speaking French a lot more (Mitchell, April 26, 2021).

Mitchell's perspective is interesting, as no ANX+ and ANX± participants reported that the recording benefited them or their interactions.

CHAPTER 5: DISCUSSION

The current study was grounded in Complex Dynamic Systems Theory and Ecological Systems Theory, arguing that the language learning process is dynamic and that it, therefore, is impacted by a myriad of factors, including individual differences (e.g., how prone a learner is to experiencing foreign language anxiety) and external factors (e.g., various learning environments and the factors within them). It also posited that lower anxiety would benefit learning, by broadening students' mental capabilities and allowing them to "build" or improve their oral performance in French.

The results and findings of the current study support these theories. Indeed, the extent to which learners experienced foreign language anxiety stemmed primarily from their individual differences (e.g., gender, time abroad, etc.) (RQ1). Likewise, the ways in which they reacted to and perceived the three learning environments were dependent upon their original anxiety profiles (ANX+, ANX±, and ANX-) (RQ2, RQ5). And finally, the lower anxiety – either perceived or physiological – afforded by virtual environments led learners to produce more comprehensible, intelligible, fluent, and complex speech, confirming the necessity to lower anxiety in order to allow language learners to perform at their best abilities (RQ3, RQ4).

Relationship between Individual Background, FLA, and Social Anxiety

The first research question of the study sought to determine how individual background differences impacted the degree to which learners reported experiencing foreign language anxiety and social anxiety. Indeed, scholars have previously argued that individual differences can influence the extent to which a learner will experience foreign language anxiety. The findings of the current study echo those of the literature.

Indeed, previous research has shown that both gender and age can interact with FLA and has predominantly found that female students reported experiencing higher foreign language anxiety than their male counterparts (Aida, 1994; Amiri & Ghonsooly, 2015; Dewaele et al., 2016; Dewaele & MacIntyre, 2014), and that Generation *Z* students are significantly more anxious than previous generations (Schroth, 2019; Seemiller & Grace, 2019). The current study confirmed previous findings and found that female students experienced higher foreign language anxiety, higher social anxiety, and significantly higher social phobia than male students. Moreover, female students also made up the majority of the ANX+ and ANX± participant groups (68.42%), furthering confirming that they are more anxious than their male peers. Moreover, regarding age, 50% of participants (aged 20.3 years old on average, i.e., born around 2001) were classified as either ANX+ or ANX±, suggesting that foreign language anxiety and social anxiety are indeed problems that are pervasive amongst Generation *Z* students entering foreign language classrooms. This also aligns with previous research that has found Generation *Z* to have higher stress levels than previous generations (American Psychological Association, 2018).

Regarding experience with the French language, it was found that participants who had started learning French earlier also had significantly lower FLA than those who began later. This is not surprising, as studying French for a longer period of time could allow learners to become more comfortable using the language. However, this does contradict the findings of the pilot study, which found that those participants who started learning French later actually had lower FLA. Moreover, it was found that participants who had had substantial prior immersion in a Francophone country had lower FLA than those who had not. While this finding must be interpreted cautiously due to the small sample size (31.58% of participants, i.e., 12 out of 38 students), these results are in line with previous research that has argued that time abroad leads to lower levels of FLA (Allen & Herron, 2003). This finding is not surprising, as time immersed in the target language and culture provides language learners with more opportunities to practice and become more competent and confident in their language skills. Lastly, participants who had experience with at least one other foreign language aside from French were also found to have lower FLA, which aligns with previous research showing that previous experience learning other foreign languages typically leads to lower anxiety (Dewaele & MacIntyre, 2014).

This study also investigated whether FLA and general social anxiety were related, as it has been argued that FLA stems primarily from the social and communicative aspects of language learning and can therefore be considered a type of social anxiety (Botes et al., 2020; Dewaele & Alfawzan, 2018). The results of the current study support this argument and found that foreign language anxiety was strongly positively correlated with social interaction anxiety and social phobia. Participants who had been previously clinically diagnosed with an anxiety disorder were also found to have significantly higher FLA. This is important, since it has been found that Generation Z students are significantly more anxious than previous generations (Schroth, 2019; Seemiller & Grace, 2019). Given the interconnectedness of social anxiety and foreign language anxiety, it is important for language teachers to actively look for ways to alleviate anxiety in their classrooms with Generation *Z* students in order to help them be more successful language learners.

This study found that certain individual factors (e.g., being female, being part of Gen *Z*, learning French later in life, etc.) made students more prone to experiencing foreign language anxiety. Although teachers cannot change their students' backgrounds, they can be aware of certain factors within them that could make students more prone to foreign language anxiety. Being aware of these factors is especially important, since anxiety can influence both individual students' learning processes but also overall classroom dynamics. For example, the vast majority of students enrolled in university-level language courses belong to Generation *Z*. Female students also often outnumber male students in language courses (Wightman, 2020). Taken together, these two factors alone can result in a class of students who are particularly anxious, emphasizing the need for teachers to find ways to alleviate anxiety in order to help their students reach their full potential. While one way could be to integrate VR technology into the curriculum, teachers could also keep in mind certain fears that lead to foreign language anxiety (e.g., fear of negative evaluation) and consider those when designing the types of activities students will do in class.

Impact of Environment on Self-Reported and Physiological Anxiety

Self-Reported Anxiety

The second research question of this study explored whether the environment that students experienced (i.e., either traditional classroom, *Zoom*, or virtual reality) impacted their level of self-reported or physiological anxiety (i.e., heart rate).

Regarding self-reported anxiety, as a whole, participants' scores were fairly stable across environments. However, they were slightly lower in classroom and *Zoom* tasks, suggesting that perhaps learners perceived they were more comfortable in these two environments. This would not be surprising, given that students were quite accustomed to both in-person and online (via *Zoom*) coursework during the pandemic. Furthermore, VR could have added technological challenges due to the novelty it represented as a learning environment that students had never experienced before, which could have subsequently increased perceived anxiety. Moreover, within each environment, self-reported anxiety scores lowered throughout the semester, indicating that students became more comfortable over time and as they became accustomed to producing language in the consensus-building activities. In terms of each anxiety group (i.e., ANX+, ANX±, and ANX-), ANX- participants reported the lowest scores after each activity, followed by ANX±, and ANX+, which demonstrates that participants' initial anxiety profiles were indicative of the subsequent type of awareness of anxiety they had for the various tasks.

Upon further delving into how each specific anxiety group responded to the three learning environments, several notable differences emerged. Concerning ANX- participants, they had the lowest anxiety in *Zoom* and classroom tasks, which is again not surprising. Given that these participants should have been equally comfortable in all three environments, VR probably presented an additional challenge to them compared to classroom or *Zoom* tasks. Moreover, these participants' qualitative interview data frequently highlighted that although they enjoyed VR and found that it provided them the chance to be immersed in realistic, contextually relevant locations, they did not necessarily feel less anxious in VR and also felt that the set up took longer than in the other environments. This additional set up could have led to these participants ranking their anxiety slightly higher than during classroom and *Zoom* tasks. This could indicate that VR, as a new environment, presents a learning curve that non-anxious students must overcome before possibly being able to experience the type of added value that VR's affordances (i.e., the potential of a particular property of the technology (Mroz, 2015)) are supposed to offer. That being said, practitioners hoping to integrate VR into their language classrooms should be mindful of the fact that extensive technological training might be necessary for lower anxiety students to be able to quickly use the technology and more readily see the benefits of using VR.

Concerning ANX± and ANX+ participants, both of these participant groups were less anxious in the virtual environments. Specifically, while more at ease in both *Zoom* and VR compared to the classroom, ANX± participants self-reported slightly lower anxiety during *Zoom* tasks, and many mentioned during the debriefing interviews that this was due to them being so accustomed to taking courses on *Zoom* during the COVID-19 pandemic. Conversely, ANX+

participants were the most at ease in VR, with many of them highlighting VR's ability to shield them from others via an avatar as the primary reason for this. Interestingly, ANX+ participants' self-reported anxiety also increased over time within the *Zoom* environment, which is the opposite of what would be expected. Perhaps an explanation for this could be that as the pandemic continued longer than many students initially expected, *Zoom* courses became the symbol of a more predominant source of stress for students who already had heightened anxiety.

Physiological Anxiety

Heart rate data was also captured from participants in order to implicitly measure their internal physical changes in response to the different learning environments. Participants' heart rate data suggested that they were less anxious in the virtual environments compared to the classroom. Indeed, as a whole, participants had the lowest HR in VR and *Zoom* tasks. They also had a decrease from their baseline HR during VR and *Zoom* tasks, but an *increase* during the classroom tasks. These objective measures suggest that even students who were not aware that they experienced lower anxiety in VR benefited physiologically from being immersed in the virtual environment. Furthermore, participants had an increase in mean HR throughout the semester for classroom tasks, an increase followed by a decrease for VR tasks, and a continual decrease for *Zoom* tasks, suggesting that students became more comfortable in the two online environments compared to the real-life environment throughout the semester.

When examining each individual anxiety group, notable differences again emerged. Specifically, ANX+ and ANX± participants were found to have higher HRs than their ANX- peers. Moreover, ANX+ students had the lowest HR in VR, followed by *Zoom* and then the classroom, which aligns with their self-reported data and further demonstrates that they were the least anxious during VR sessions. Although ANX± self-reported slightly lower anxiety on *Zoom*, they also had the lowest HR in VR, followed by Zoom and then the classroom, indicating that VR at a minimum benefited their physiological manifestations of anxiety. This is important, as it suggests that these students were still the most physiologically at ease in VR despite not being as familiar with it compared to *Zoom*. Perhaps if students had been equally exposed to both virtual environments, they would have also had lower self-reported anxiety during VR tasks. Finally, ANX- had the lowest HR on *Zoom*, followed by VR and then the classroom. This suggests that although these participants self-reported the lowest anxiety in the classroom, they were the least physiologically at ease in this more traditional learning environment. It is again not surprising that these participants were so comfortable on *Zoom* given their extended experience using the video-conferencing platform during the COVID-19 pandemic. However, it is critical to note that even students who reported feeling more comfortable in the classroom had negative physiological side effects from this more traditional learning atmosphere.

Self-Reported and Physiological Anxiety

Unsurprisingly, the extent to which participants experienced anxiety across the three learning environments was linked to how anxious they were initially and their specific anxiety profile. However, the fact that ANX+ and ANX± participants had lower self-reported anxiety in virtual environments and that all participants, including those that were ANX-, had lower physiological measures of stress in these environments aligns with previous research examining the relationship between anxiety and virtual learning environments. Indeed, several scholars have argued that language learners, particularly those who have high foreign language anxiety (Handley, 2018), will experience lower anxiety when completing speaking tasks in virtual learning environments compared to a traditional face-to-face classroom (Gruber & Kaplan-Rakowski, 2020 & 2021; Liaw, 2019; Xie et al., 2019; York et al., 2021). This study further confirms that VR can provide a low-stress, authentic learning environment in which learners can feel at ease conversing in the respective target language. Moreover, the majority of previous studies have examined the impact of VR on anxiety qualitatively and have not empirically measured how learners' anxiety varies across various learning environments (Xie et al., 2019). There has also been a complete lack of research published on VR and FLA that incorporates physiological measures of anxiety (Xie et al., 2019). This study aimed to address these two research gaps, by complementing participants' self-reported data with heart rate data. Furthermore, participants' self-reported data was not always congruent with heart rate measures, suggesting that these two measures allow to assess two different (albeit related) facets of anxiety, both of which can be of interest. Specifically, self-reported data measures participants' perceptions of their anxiety, while HR can be incorporated to measure how anxiety fluctuates throughout a task and the extent to which different learning environments impact learners' stress physiologically.

The participants in the current study also had low anxiety overall during *Zoom* tasks. This is important, as previous research that has examined how video-conferencing platforms impact learners' FLA has yielded mixed results (Punar & Uzon, 2019; Terantino, 2014; York et al., 2021). However, it should be noted that the previous research published thus far was conducted prior to the COVID-19 pandemic. Given the repeated, frequent use of *Zoom* during this period, it is not surprising that learners would perceive it differently than during pre-pandemic times. The results of the current study therefore seem to suggest that using *Zoom* constantly during COVID-19 allowed students to become more comfortable with the platform which led to lower anxiety during *Zoom* tasks in the current study.

Finally, as each anxiety group responded differently to the three learning environments, it is important for language teachers to be mindful of this when trying to use VR with their students. Specifically, students should be provided with extensive training on how to use the technology in order to alleviate some frustration or anxiety that could stem from technological difficulties for ANX- and ANX± students. Moreover, although *Zoom* may be easier to navigate initially due to familiarity, ANX+ students' increase in anxiety over time in this setting indicates that it is perhaps not the best learning environment long-term for them to be able to feel comfortable and be successful when learning and conversing in the target language. Furthermore, the current study found that even students with low foreign language anxiety had lower heart rates in the virtual environments, demonstrating that even students who were expected to be equally at ease in all learning environments benefited physiologically from being immersed in VR. This is important, as it shows that all students, regardless of their anxiety profiles, can benefit from VR. Given the debilitating impact of anxiety on language learning, it is crucial for language teachers to set their students up for success by immersing them in an environment that can optimize their learning experience.

Impact of Environment and Anxiety on Oral Measures

This study also examined whether and how being immersed in the three different learning environments impacted learners' comprehensibility, intelligibility, and fluency when students were engaged in spontaneous interpersonal consensus building tasks with their peers.

In terms of *comprehensibility* and *intelligibility*, the native French-speaking raters found participants to be significantly more comprehensible and intelligible in both the VR1 and Z1 tasks compared to the CR1 task. Participants were also found to be more comprehensible and intelligible in the VR2 and Z2 tasks when compared to the CR2 task, indicating that their L2 oral production benefited from being in the virtual environments. When comparing the two virtual environments, participants were found to be both more comprehensible and intelligible during the VR1 and VR3 tasks compared to the corresponding Zoom activities, although less intelligible in the VR2 task compared to the Z2 task. This could suggest that conversing in VR benefited participants' speech slightly more than on *Zoom*, though more research would be needed to test this claim. Similar to the pilot study results, participants also became more comprehensible and intelligible in each environment over the course of the semester, suggesting that they were able to improve their pronunciation as a whole regardless of the learning environment. Moreover, results from RQ2, examining the impact of the environment on anxiety, indicated that learners were physiologically overall more at ease in the virtual environments compared to the classroom. Taken together, these results seem to indicate that being in a virtual environment did indeed lessen anxiety in learners and positively impact their oral production by leading them to produce more comprehensible and intelligible speech. This aligns with the Broaden-and-Build Theory which framed this study and argued that lower anxiety can lead to positive emotions that lead to better learning, problem solving, and performance (Boudreau et al., 2018; Gregersen et al., 2014; Isgett & Frederickson, 2015; Shirvan et al., 2020). This also confirms the need for language teachers to consider how the learning environment impacts learners' emotions, with the aim of creating a low-stress environment that allows students to broaden their thinking and build, or produce, stronger language. Finally, students who demonstrated lower levels of self-reported anxiety (ANX-) were found to be more comprehensible overall, confirming the need once again make students feel like they are less anxious in order to aid them in more successfully producing the target language during spontaneous interactions. However, interestingly, ANX+ participants were found to be more intelligible than their ANX- and ANX± peers, which contradicts previous research. Results to RQ3 about the relationship between fluency and intelligibility, addressed below, will allow to cast a light on what might have happened.

The fact that learners were more comprehensible and intelligible in what was perceived as lower-stress virtual environments corroborates previous research examining the influence of anxiety on pronunciation and whether and how virtual environments impact FLA. Indeed, previous research has also found that anxiety negatively impacts pronunciation in a foreign language, since muscle tension can limit the articulatory potential of learners (Feigenbaum, 2007; Khoroshilova, 2016; Szyszka, 2017). Moreover, several CALL researchers have found that virtual environments can aid in lowering anxiety in language learners specifically during speaking tasks (Gruber & Kaplan-Rakowski, 2020 & 2021; Liaw, 2019; Xie et al., 2019; York et al., 2021). This is particularly important, as learners need to be able to produce comprehensible and intelligible speech in order to communicate effectively in the target language. Furthermore, it is also not surprising that these participants would experience lower anxiety on *Zoom* that benefited their oral production since they have become so accustomed to *Zoom* interactions since the start of the COVID-19 pandemic, although previous research examining the rapport between *Zoom* and FLA has yielded mixed results (Punar & Uzun, 2019; Terantino, 2014; York et al., 2021). However, the current study expanded previous research considerably by the addition of physiological measures of anxiety and complementary measures of pronunciation. Therefore, it is crucial to note that comprehensibility and intelligibility were positively influenced by the learning environments that contributed to lower anxiety (i.e., VR and *Zoom*), as these two measures are representative of learners' pronunciation.

Moreover, contrary to what was found in the pilot study, participants were also more fluent in *VR* than on *Zoom* or in the classroom. Specifically, participants produced on average

1.69 and 1.88 more words in the 20-second speech samples in the VR1 task compared to the Z1 and CR1 tasks respectively and .766 and 1.321 in the VR2 task compared to the corresponding Z2 and CR2 tasks. Participants were also slightly more fluent in the VR3 task compared to the Z3 task. Indeed, it seems that VR's ability to reduce distractions and help learners focus solely on the task at hand enabled them to produce more fluent speech. Furthermore, participants also became more fluent within each environment over the course of the semester. Finally, as with comprehensibility, ANX- participants were found to be more fluent than their ANX± and ANX+ peers. These results support previous research that has argued that lower anxiety leads to better fluency (Aida, 1994; Castillejo, 2019; MacIntyre & Gardner, 1994a & 1994b; Sanaei et al., 2015) and also coincides with qualitative data from the semi-structured interviews where participants reported feeling that they could express themselves more easily in French in VR since they were more relaxed and also since they were able to reduce outside distractors and uniquely focus on the consensus-building activities.

Finally, RQ3 also aimed to determine whether participants' comprehensibility, intelligibility, and fluency scores were related. Significant correlations were found between all three speech measures, confirming a relationship between them (Derwing & Munro, 1997). However, while significant positive correlations were found between comprehensibility and intelligibility and comprehensibility and fluency -- indicating that as one improved, so did the other -- a negative correlation was found between intelligibility and fluency, indicating that the more words students produced per 20-second sample, the less intelligible they became. Reflecting back on the results where ANX+ participants displayed higher intelligibility, an explanation for this could be that since intelligibility was measured by having the native speakers transcribe participants' speech after hearing the sample one time, perhaps the more words a student produced, the harder it was to remember the entire message, thus resulting in a lower intelligibility score.

Comprehensibility, intelligibility, and fluency are all vital for being able to successfully communicate in the target language. The current study found that the lower anxiety afforded by VR led to an improvement for all three of these speech measures. Moreover, it seems that VR's ability to fully-immerse students and block out the outside world allowed them to focus more on the task at hand and produce more fluent speech. In terms of integrating VR into the language classroom, this suggests that it is especially beneficial for practicing oral skills and doing speaking activities. Furthermore, considering that having to speak in a foreign language is often considered by learners to be the most anxiety-inducing task, VR could provide a safe and effective environment for learners to practice this skill in, before applying it in the real-world.

Anxiety and Oral Production at the Individual Level

This study also aimed to examine how anxiety and oral production were impacted at the individual level in two three-participant focus groups throughout each activity within the three different learning environments (RQ4). Merging transcriptions of participants' group interactions that had been coded using the Interaction Analysis Model (Hull & Saxon, 2008) with participants' heart rate data, self-reported anxiety data, and comprehensibility, intelligibility, and fluency scores allowed to get a more in-depth understanding of how participants' speech and complexity of discourse were impacted dynamically by both their physiological and self-reported anxiety as well as how their real-time physiological response impacted their speech during each task.

As a whole, participants in the first focus group (Samantha (ANX+), Jessica (ANX+), and Nick (ANX-)) self-reported the lowest anxiety during the VR tasks. Based on the results from RQ2, this was not surprising for Samantha and Jessica, since they were both ANX+

participants and therefore were expected to benefit from being immersed in VR in terms of their anxiety. It was surprising though that Nick (ANX-) reported substantially lower anxiety in VR compared to the classroom, considering one would expect him to be equally at ease in all three learning environments. However, Nick (ANX-) repeatedly mentioned that both the classroom environment and the *Zoom* environment were constant reminders of the on-going COVID-19 pandemic (e.g., masks, physical social distancing, social isolation online), which could explain the differences in his self-reported anxiety scores. Moreover, it should be noted that Nick (ANX-) found *Zoom* classes so anxiety-inducing that it even manifested in him refusing to attend *Zoom* sessions, which could have harmed his language learning. As a whole, these participants' heart rate data mirrored the self-reported anxiety data, with participants' mean HRs typically being lower during the virtual tasks compared to the classroom.

In terms of participants' discourse, Jessica (ANX+) and Nick (ANX-) benefited from the virtual environments and from the lower anxiety that they afforded them. Indeed, Jessica (ANX+) spoke the most during the VR1 and VR2 tasks and also reached her highest levels of discourse during the VR1, VR2, and Z2 tasks. Similarly, Nick (ANX-), spoke substantially more and reached his highest levels of discourse during the VR1 and VR2 tasks. This is important, as it indicates that even for ANX- participants, being less stressed in the VR environment allowed them to produce substantially more complex language and have more advanced discussions in French. Samantha (ANX+) had more mixed results. She spoke the most during the CR1 tasks (when her self-reported anxiety was at its highest), and she reached her highest levels of discourse during the CR1 and Z2 tasks when she also had high self-reported anxiety. This is interesting, as we would expect for Samantha (ANX+) to perform at her best when her anxiety was the lowest (i.e., during the VR1 task). Perhaps an explanation for this could be that, although relaxed, Samantha (ANX+) was distracted during the first VR task since she was still getting used to the equipment and environments despite attending both training sessions. Unfortunately, Samantha (ANX+) could not attend the second VR session, so it is not possible to see if a similar pattern emerged once she was more accustomed to using the equipment.

Regarding the more specific measures of these participants' speech (i.e., comprehensibility, intelligibility, and fluency), Jessica (ANX+) was the most comprehensible during the VR and Zoom tasks, the most intelligible during the VR tasks, and the most fluent during the second Zoom task. Nick (ANX+) was the most comprehensible, intelligible, and fluent during the VR tasks. These results mirror the Interaction Analysis Model findings, suggesting that Jessica (ANX+) and Nick (ANX-)'s speech benefited from being in the virtual environments at the level of both pronunciation and complexity. Lastly, Samantha (ANX+) was the most comprehensible and intelligible during the VR1, CR2, and Z2 tasks and the most fluent during the CR2 and Z2 tasks. This does not necessarily mirror Samantha's (ANX+) Interaction Analysis Model findings and suggests that her pronunciation accuracy and discourse complexity were not necessarily related during the tasks.

Tracking how participants' heart rates unfolded in response to their group interactions allowed to pinpoint specific factors that contributed to fluctuations in heart rate in each learning environment. For Jessica (ANX+), her heart rate increased during classroom tasks when she would raise the conversation to a higher level of discourse (e.g., level 4 (intersubjective dissonance) or 5 (negotiation and co-construction of meaning)), when she experienced linguistic breakdowns, and when she had disagreements with her group members. Conversely, her heart rate decreased when she was playing a passive role in the conversation or when her group discussed other things not pertaining to the task at hand (e.g., the 2020 presidential elections).

This is not surprising, as we would expect that producing more complex thoughts in French and having linguistic breakdowns would stoke Jessica's (ANX+) anxiety. During *Zoom* tasks, Jessica's (ANX+) heart rate increased notably when she was producing lower-level discourse in English and when the researcher was present but decreased when she was producing higher-levels of discourse (e.g., level 4 or 5) and when experiencing linguistic breakdowns. This is interesting, since producing higher levels of discourse and having linguistic breakdowns were the exact causes of increases in Jessica's (ANX+) heart rate during classroom tasks. Perhaps an explanation could be that being more relaxed overall in a virtual environment made Jessica (ANX+) less susceptible to having physiological responses to these difficulties and ultimately benefited her anxiety. For VR activities, Jessica's heart rate again increased when having casual, informal exchanges not pertaining to the task and decreased when she experienced linguistic breakdown. This again supports the hypothesis that being more at-ease in the virtual environments made Jessica (ANX+) less susceptible to physiological responses. Moreover, perhaps the reason for which Jessica (ANX+) experienced an increase in anxiety when having informal conversations that were off topic could be that she was afraid of the researcher watching her group's recorded conversation later and seeing that the group had been momentarily distracted.

For Nick (ANX-), his heart rate increased during classroom tasks notably when he would have linguistic breakdowns, when mentioning the COVID-19 pandemic and safety measures, and when mentioning the 2020 presidential elections. Conversely, his heart rate only decreased when he was playing a passive role in the conversation and not really producing any speech in French. This is not surprising, as linguistic breakdowns led to a physiological response for most participants and since Nick (ANX-) vocally expressed that he was stressed by both the COVID-

19 pandemic and the elections during the tasks themselves. However, for the VR tasks, Nick's (ANX-) heart rate also increased when he mentioned the COVID-19 pandemic, but either decreased or remained stable when having linguistic breakdown, negotiating misunderstandings or disagreements with his peers, saying he was stressed that the researcher was present, and having casual exchanges with his classmates. As with Jessica (ANX+), perhaps Nick (ANX-) was relaxed enough in the VR environment to where he did not respond physiologically to certain stressors in the same way as in the classroom, except for the COVID-19 pandemic which was clearly an on-going cause of anxiety for him. The extent to which this external factor impacted his anxiety during French class emphasizes the need to consider as many factors as logistically possible when evaluating how and why anxiety fluctuates.

Lastly, for Samantha (ANX+), her heart rate increased during classroom tasks when she would have linguistic breakdowns or disagreements with her peers and decreased when she was playing a more passive role in the conversation and simply listening or agreeing with other's ideas. For the Zoom tasks, her heart rate increased again when she was playing a more active role or when Zoom would cut out and cause momentarily communication difficulties and decreased when she was listening more passively or reading directions. Both of these responses are what we would expect to see, suggesting that Samantha (ANX+) did not necessarily benefit physiologically speaking from being on *Zoom* vs. in the classroom. However, it does highlight one of the reasons for which *Zoom* interactions could increase anxiety.

For the second focus group (Rick (ANX-), Rohan (ANX-), and Amanda (ANX+)), Rick (ANX-) reported the lowest anxiety in classroom and *Zoom* tasks, Rohan (ANX-) the lowest in classroom and VR tasks, and Amanda (ANX+) the lowest in VR tasks. This is surprising, since Rick (ANX-) and Rohan (ANX-) would be expected to be equally comfortable in all learning environments. However, perhaps VR presented an additional technological challenge for them that contributed to their anxiety. On the contrary, it would be expected that Amanda as an ANX+ participant would feel more comfortable in the VR environment since she was shielded by her peers and not physically seen. For Rick (ANX-) and Rohan (ANX-), their heart rate data did not necessarily coincide with their self-reported anxiety data. Indeed, Rick (ANX-) had the lowest mean heart rate during the VR1, CR1, and VR2 tasks and Rohan (ANX-) had the lowest mean heart rate during the Z2 and CR2 tasks. This coincides with results from RQ2 which showed that although ANX- did not perceive lower anxiety in VR, they did benefit physiologically from being in the two virtual environments. However, for Amanda (ANX+), her heart rate was lowest in VR when also self-reporting the lowest anxiety.

Regarding their discourse, all three members of the focus group seemed to have benefited from being in VR and, for Amanda (ANX+), the lower anxiety that accompanied it. Indeed, Rick (ANX-) spoke the most and reached his highest, most complex level of discourse during the VR1 task, Rohan (ANX-) overall spoke more and reached his highest levels of discourse in VR and *Zoom* tasks, and Amanda (ANX+) spoke substantially more and only reached higher levels of discourse while in VR. For Amanda, this suggests that as an ANX+ participant, her oral production in French improved when she was more relaxed and immersed in the VR setting and not having to communicate with her group members face-to-face or via a video-camera. For Rick (ANX-) and Rohan (ANX-), perhaps VR's immersiveness and ability to remove outside distractions allowed them to focus solely on the task at hand and have more complex interpersonal exchanges with their peers.

In terms of the more specific aspects of these participants' speech (i.e., comprehensibility, intelligibility, and fluency), Rick (ANX-) received very similar comprehensibility scores across all environments. However, his intelligibility and fluency were overall higher during the VR tasks. Rohan (ANX-) was the most comprehensible during Zoom tasks and the most intelligible and fluent during VR tasks. Finally, Amanda (ANX+) was most comprehensible and fluent during the VR tasks and most intelligible during the *Zoom* tasks. As with the first focus group, these results mirror the Interaction Analysis Model findings, suggesting that this group's speech also benefited from being in virtual environments, primarily VR but also to a certain extent *Zoom*, at the level of both pronunciation and complexity.

As with the first focus group, tracking of how these participants' heart rates fluctuated in response to their ongoing interactions brought to light specific factors that contributed to fluctuations in heart rate in each environment for each participant. For Rick (ANX-), his heart rate increased during classroom tasks when he was leading the conversation and when he was producing longer utterances but decreased when he conversed with ease even at higher levels of discourse, when he was playing a more passive role in the conversation, and when he was producing short utterances. This is not surprising, as we would expect for conversing with ease (as opposed to experiencing linguistic breakdown) and producing shorter utterances would momentarily boost confidence and lower anxiety. For virtual tasks, Rick's (ANX-) heart rate was much more stable. Indeed, in *Zoom* he only had increases in heart rate when making longer contributions to the conversation – similar to what was seen during classroom tasks. In VR though, he had decreases in heart rate when producing shorter utterances, when joking around with his peers, when the teacher was present, and even when he had trouble expressing himself. This indicates that although Rick was comfortable in all environments as an ANX- participant, he was still less susceptible to physiological responses in VR even when experiencing linguistic breakdown.

For Rohan (ANX-), his heart rate increased in the classroom when he was playing a passive role, when he could not find appropriate words to express himself and had to rely on gestures, and when he was producing longer utterances. It decreased when he was communicating with ease and producing shorter utterances. This is overall what we would expect to see. However, it is surprising that Rohan's (ANX-) heart rate increased while he was playing a passive role during the second classroom task. Perhaps an explanation could be that this passivity was the exact factor stoking his anxiety, in that he felt anxiety-inducing pressure to participate in the conversation his peers were having. During *Zoom* tasks, Rohan (ANX-) had an increase in anxiety when again playing a passive role, when he was prompted by Rick (ANX-) to answer a question, when experiencing linguistic breakdown, when making longer contributions, and when being told that the group would soon return to the main Zoom room with the other classmates to share what they had all discussed as a whole class. Again, this is not surprising and Rohan's (ANX-) reaction to being told that his group would momentarily share their ideas with the class coincides with previous research that has argued that having to speak in front of other students is a common cause of foreign language anxiety since students often are afraid of negative evaluation (Aslan & Sahin, 2020; Boudreau et al., 2020; Dewaele & Dewaele, 2017; Fondo et al., 2018; Shirvan & Talebzadeh, 2020; Vo et al., 2017; Zheng & Cheng, 2018). Finally, for VR tasks, Rohan (ANX-) had an increase in anxiety again when searching for the right words to express himself, when the teacher was silently observing his group, when he was being particularly passive and not contributing to the conversation, and when his group was joking around. This is interesting, because it would be expected that less formal exchanges with his peers (i.e., when they were joking) would momentarily lower his anxiety. However, perhaps like

Jessica (ANX+), Rohan (ANX-) was concerned about the researcher watching the video footage back and seeing that the group was momentarily joking about the task at hand.

Finally, for Amanda (ANX+), she had increases in heart rate during the classroom at the beginning when her group was not getting started but decreases even when she was having linguistic breakdowns. Indeed, at one point in the conversation, Amanda (ANX+) was unable to express herself accordingly. However, she was able to circumnavigate the situation by using other words to get her point across, which could have been why she did not experience an increase in anxiety when we would expect her to. During *Zoom* activities, her heart rate increased when she was making longer contributions, which is what would be expected. However, she stopped having increases in heart rate in response to longer utterances the longer the task went on, suggesting that she became more comfortable throughout the specific activity. Finally, in VR, Amanda (ANX+) had increases in heart rate when speaking at her highest levels of discourse in all the tasks (i.e., level 6 (testing tentative constructions) & 7 (reporting newly co-constructed knowledge)), although this did not impact her performance at the production level. Like Rick (ANX-), her heart rate also decreased when joking around with her group, suggesting that this less-formal interaction alleviated her anxiety momentarily.

Analyzing the focus group participants' conversations and heart rate data allowed to pinpoint specific moments where anxiety ebbed and flowed throughout the tasks in the three different learning environments. This revealed that each individual participant responded to elements in each learning environment differently and emphasized the personal nature of anxiety. In terms of VR, it also revealed that participants, particularly those who were ANX+, produced substantially more discourse at higher levels when immersed in the VR environment. Furthermore, participants were also less susceptible physiologically to potential stressors (e.g., linguistic breakdown) when in the virtual environments. This is important, as being able to produce language at higher levels and ultimately co-construct meaning with their peers can lead to further learning in the language.

Student Perceptions

Another main purpose of the current study was to examine how participants perceived the three learning environments impacted their anxiety and language learning. In order to do so, two key things were examined: (1) whether a relationship existed between the degree of presence experienced by participants in VR and their self-reported anxiety scores and (2) participants' qualitative interview data.

Participants' presence data revealed that those who felt more present in the VR environments were also those who felt the least anxious during tasks. This is important, as lower anxiety was found to benefit performance in VR, thus supporting previous research that has argued that VR's ability to induce a high degree of presence can benefit the language learning process (Lan et al., 2015; Liu et al., 2017). Moreover, practitioners should keep this in mind when assessing VR platforms for pedagogical potential in order to make sure that they choose one that maximizes presence and, subsequently, learning.

Regarding participants' qualitative interview data, it was found that participants' perceptions of the three learning environments depended upon their anxiety profiles (ANX+, ANX±, or ANX-) and their immersive tendencies (e.g., how prone they were to feeling immersed in virtual spaces).

ANX+ participants reported feeling much more relaxed and at ease in virtual environments compared to the traditional classroom. This was partly due to the fact that they could participate from the comfort of their own homes when doing virtual activities. However, these participants' anxiety was also greatly impacted by the degree to which their peers could see them, with participants frequently comparing the extent to which they were seen by others in the three environments. For these high anxiety participants, being shielded behind an avatar in VR and not having to make eye contact or worry about how they looked made them the most comfortable and allowed them to express themselves better in French. Although less so than in VR, these participants also found *Zoom* activities to be less-anxiety inducing than classroom activities since they were still able to avoid direct eye contact through the computer screen. It should be noted though that one ANX+ participant, Melanie, did find the lack of visual contact and cues in VR to exacerbate her anxiety since she relied greatly on gestures to communicate in French. However, Melanie also had lower foreign language abilities than her classmates, which could indicate that VR might not be best to use with lower-level language learners who do still rely heavily on visual cues, but that it instead might be more appropriate for more advanced speakers. This would support previous work by Satar and Ozdener (2008) who found that while a lack of visual cues can reduce anxiety for some language learners, it can make it more difficult to communicate for those who have lower proficiency levels. Lastly, ANX+ participants also reported that the presence of the main researcher contributed to their anxiety, mostly because they were afraid of being evaluated negatively and judged for their French abilities. This finding echoes previous research that has found that foreign language anxiety often stems from students being afraid of being negatively perceived and evaluated by those around them (Aslan & Sahin, 2020; Boudreau et al., 2020; Dewaele & Dewaele, 2017; Fondo et al., 2018; Ipek, 2016; Khoroshilova, 2016; Maria-Signona & Barros-Del Rio, 2016; Shirvan & Talebzadeh, 2020; Vo et al., 2017; Zheng & Cheng, 2018).

ANX+ participants also found the VR environments to be immersive, fun, enjoyable, and easy to use. Indeed, even though *vTime XR* is quite cartoonish, the 360° 3D space allowed participants to still be able to achieve suspension of disbelief (Mroz, 2012) and feel as if they were truly inside the VR environment. Only for Melanie, who was the lowest ANX+ participant on the Immersive Tendencies Continuum, was this immersion a negative thing. Indeed, for her, the fact that *vTime XR* users are stationary in one location while talking made her feel like she was experiencing sleep paralysis. This comparison is important, as being limited to having to stay seated can be considered a drawback of the *vTime XR* application. Perhaps having a VR application that allows students to walk around is necessary in order for those who have lower immersive tendencies to really feel as though they are inside the environment. Finally, these participants found the VR equipment and platform easy to use and navigate. They also reported that they were quite accustomed to navigating *Zoom* since the COVID-19 pandemic had forced them to complete most of their coursework online and that they enjoyed being able to look up vocabulary easily while engaging in *Zoom* activities. Compared to the classroom, these participants found that both *Zoom* and VR were less distracting and that it was easier to communicate when using them since there were no COVID-19 protocols in place (e.g., social distancing, masks).

Similar to ANX+ participants, ANX± also talked about being more at ease and comfortable in VR. However, for these participants, this lower anxiety stemmed less from not being seen by others (aside from Hannah who did mention being more comfortable when hidden behind an avatar) and more from experiencing the different VR locations. Indeed, these participants mentioned that VR felt like a game, that it was more casual, and that certain environments (e.g., the Japan House) were particularly tranquil and led to them feeling calmer during those activities. In line again with ANX+ participants, several ANX± students, particularly those higher on the anxiety continuum, mentioned that the presence of the main researcher contributed to their anxiety. Again, these students were concerned with being negatively evaluated and judged for their French abilities or for making mistakes in the language. Interestingly though, none of these students reported that their peers contributed to their anxiety. Instead, only Mark noted that he experienced frustration when one of his group members would come to class unprepared and cause them to be delayed with starting the activities.

ANX± participants also thought the environments were immersive and that they added to the experience by giving them ideas to discuss with their peers and also allowing them to escape *Zoom* fatigue and immerse themselves in a new location during the COVID-19 pandemic. This finding aligns with the sociocultural paradigm that framed the current study and argued that L2 interactions and learning benefit from occurring in a relevant, appropriate context (Gánem-Gutiérrez, 2018; Grazzi, 2018; Lin et al., 2015; Satar & Ozdener, 2008). Moreover, these students also found that VR reduced distractions (e.g., texts, emails, etc.) that they would still have access to on *Zoom*. This is important, as opponents of VR could argue that it is distracting and too gimmicky for students. For these students though, the full immersion allowed them to focus solely on the task at hand. However, for one participant, Riley, this full immersion made her a bit anxious since she had to only rely on the linguistic knowledge she had and could not easily look up words in VR compared to on *Zoom*. It should be noted though that this simulation of real-life situations where students must rely on the language they have and interact spontaneously could be seen as beneficial for language learning. Overall, ANX± participants also noted that the VR equipment and platform were easy to use. However, a few students did note that *Zoom* activities felt easier to do logistically speaking, since there was no additional set up (e.g., charging VR headset, ensuring it was connected to Wi-Fi, etc.) and since they were so accustomed to using *Zoom* every day. This finding reiterates previous research that has found that connection issues can cause challenges when using VR (Kaplan-Rakowski & Meseberg, 2018).

Different from ANX+ and ANX± participants, ANX- students reported feeling comfortable during all activities, regardless of the environment in which they occurred. However, these participants did note that the VR visuals and sound effects put them at ease and that they enjoyed the variety of locations that *vTime XR* offered. These participants also were the first to comment on how the different roles they were playing made them more relaxed. Specifically, Mason noted that he felt more at ease when playing roles such as the director or boss, because he felt he could just listen to the ideas of his classmates. For Nicole, she mentioned that she was more comfortable when the roles allowed her to be silly. Both of these students' comments confirm previous research that has found role playing to contribute to lower anxiety (Boudreau et al., 2020; Dewaele & Dewaele, 2017). These participants also mentioned several factors that made them uncomfortable during tasks, notably interactions with peers that were either difficult or awkward due to differences in linguistic abilities or reminders of the COVID-19 pandemic. Indeed, for Nick, the stress stemming from the COVID-19 pandemic was so severe that he actually reported avoiding all *Zoom* sessions specifically because they reminded him too much of the on-going health crisis.

ANX- participants also thought that the *vTime XR* environments were immersive and enjoyable to interact in. Specifically, they found that VR provided a fun, game-like element to their class sessions and that it broke up the monotony of always using *Zoom*. These participants also noted that the environments felt natural and immersive and that they cut out a lot of the distractions that were present in the other two learning environments. Moreover, these participants also thought that VR offered them a more realistic environment to interact in, and that this ultimately inspired them with different ideas throughout their conversations and also made their interactions more natural, since VR does not have a mute button like *Zoom*. Therefore, even though these participants could not physically see each other, they still found that VR interactions resembled in-person interactions more so than *Zoom*, since VR allowed for them to all be immersed in the virtual environment together and have more natural back-and-forth conversations. This finding aligns with previous research that has shown that participants find it easier to have conversations in VR than on Zoom despite not being able to physically see each other's faces (York et al., 2021). Furthermore, even though their group members were represented by virtual avatars, ANX- participants perceived these avatars as extensions of their peers, particularly because users' avatars resembled what they looked like in real life. Some participants even mentioned that they were able to maintain "eye contact" with their peers through their avatars. However, some of these participants, particularly those lower on the Immersive Tendencies Continuum, still reported preferring in-person interactions in order to have access to all visual cues and gestures that are used in communication. This is not surprising, as ANX- participants do not experience discomfort or anxiety during face-to-face communication like ANX+ or ANX± participants.

Lastly, ANX- participants also found that the VR was easy to use and that they did not experience any negative side effects such as headaches or nausea. This could partly be because students do remain seated while using *vTime XR*, as VR applications where users must "walk around" have been found to sometimes lead to negative physical side effects. These participants did point out though that VR requires a longer set up than *Zoom* or classroom activities. However, when asked to talk about learning on *Zoom*, these participants reported that they did not feel like they were effectively retaining information learned in their classes, that their peer interactions were negatively impacted by students turning their cameras and microphones off, and that they were exhausted by *Zoom* learning. Indeed, these participants reported that the COVID-19 pandemic had given them a newfound appreciation for in-person language learning and that they were worried about the long-term effects that *Zoom* courses will have on their learning. This is important to keep in mind since *Zoom* was the default choice for many universities during the COVID-19 pandemic when classes had to be taught virtually. Perhaps, moving forward, a better option would be to incorporate VR coursework into distant learning, since several students in the current study mentioned that it resembled in person learning and interactions more closely than *Zoom*.

Overall, all groups of participants in the current study reported that they found VR to be immersive, interesting, fun, and overall easy to use – though additional set up, compared to *Zoom* or in-person classes, was required prior to class. This echoes previous research that has shown that students find VR immersive (Huang et al., 2021; Kaplan-Rakowski & Meseberg, 2018; Kaplan-Rakowski & Wojdynski, 2018), interesting (Chateau et al., 2019; Kaplan-Rakowski & Wojdynski, 2018), and fun (Huang et al., 2021; York et al., 2021). As these perceptions could increase motivation to learn the language and participate, teachers should keep them in mind when deciding whether or not to integrate VR into their language curriculum. Moreover, other researchers have also had students comment on the technological difficulties and additional set up that VR requires (Huang et al., 2021; Kaplan-Rakowski & Meseberg, 2018; York et al., 2021), reiterating yet again the importance of proper student and teacher training when using this technology.

However, participants' reasons for liking VR varied depending on their anxiety profile. While ANX+ participants mentioned enjoying VR sessions because they were hidden from their peers and, subsequently, more comfortable, ANX± participants primarily talked about how VR relaxed them since it was fun and game-like and allowed them to escape to new locations during the pandemic. This finding supports previous research that has shown that learners are less anxious in VR when compared to traditional classroom environments (Allcoat & Muhlenen, 2018; Chateau et al., 2019; Chien et al., 2019; Gruber & Kaplan-Rakowski, 2020 & 2021; Huang et al., 2021; Kaplan-Rakowski & Wojdynski, 2018; Liaw, 2019; Peixoto et al., 2021; Xie et al., 2019; York et al., 2021), and that those who experience the greatest reduction in anxiety are those who are most anxious initially (Handley, 2018). Finally, ANX- participants liked VR mostly because they found it to be fun and interesting and that it resembled in-person interactions more than *Zoom* did. This is interesting, since ANX+ participants specifically found that VR was less stress-inducing because it did *not* resemble face-to-face interactions. This indicates that although participants' reasons for benefiting from VR language learning might vary depending on their individual backgrounds, they all found that some aspect of the technology benefited their learning process.

Caveats

This study has several limitations that should be addressed. For one, the sample size (N = 38) was smaller than originally intended and made it challenging to conduct inferential statistics. Unfortunately, during Fall 2020, there were only 8 students enrolled across both sections total of the course that participants were recruited from when, typically, there would be on average 15 students per section. While enrollment was higher in Spring 2020 and Fall 2021, it was still impossible to attain the originally planned sample size of 50. Moreover, only a very small number of ANX+ participants (n = 3) took part in the optional semi-structured interviews at the end of the study. As these participants were of particular interest, it would have been ideal to be able to conduct interviews with all of them. However, their high anxiety made them less willing to participate in this optional part of the research.

Another limitation of this study is that the course modality changed every semester due to the ever-evolving COVID-19 pandemic and safety precautions. For example, in Fall 2020 and 2021, the course was taught at least partially in person, whereas in Spring 2021, it was taught fully online and in-person data collection was not possible. To remedy this issue, Spring 2021 participants completed 3 VR tasks and 3 Zoom tasks (instead of 2 classroom, 2 VR, and 2 Zoom tasks). However, not having these participants complete classroom tasks further reduced the sample size of participants who did. Furthermore, in the preliminary pilot study, students came to the VR lab for the VR sessions, so the researcher was able to ensure that all equipment was fully charged and working beforehand. Since the current study had students complete VR sessions using their loaned VR headset from home, students were responsible for set up and sometimes came to class unprepared (e.g., forgot to charge headset, forgot to charge heart rate monitor), which resulted in data loss. However, this was also insightful in that it further highlighted the challenges that educators will face when trying to integrate VR into their teaching. Finally, some participants pointed out a key limitation of the *vTime XR* VR platform (i.e., the fact that participants must sit stationary and cannot really interact with the environments themselves). This platform was specifically chosen since oral interaction was the focus of the current study and to avoid negative physical side effects (e.g., nausea) that can stem from VR platforms that allow for more movement. However, moving forward, it would be interesting to evaluate how other types of VR environments also impact anxiety and immersion.

CHAPTER 6: CONCLUSION

The current study explored whether and how immersive virtual reality technologies can be employed to alleviate foreign language anxiety in L2 French learners with the goal to produce more comprehensible, intelligible, and fluent speech and more complex co-constructed discourse. It also examined in depth how participants' anxiety fluctuated in response to three different learning environments – VR, *Zoom*, and a traditional classroom – and their unfolding interpersonal communications. Finally, participants' perceptions of the different environments and how they impacted their learning were assessed.

Participants' self-reported anxiety data and physiological measures indicated that learners, particularly those who were more anxious initially, were less anxious overall in virtual spaces (RQ2, pp. 96-108). Participants were also found to be more comprehensible, intelligible, and fluent in VR and when they were less anxious (RQ3, pp. 108-121), confirming the beneficial impact of VR for language learning and the need to alleviate anxiety in learners to enable them to be more successful. Furthermore, analyses of how focus group participants' heart rates evolved throughout activities in response to their unfolding conversations and the surrounding environment brought to light various factors within each learning environment that both alleviated and worsened anxiety (RQ4, pp. 121-207). Finally, participants' insights into how they experienced the three environments indicated that learners were overall more at ease in the virtual environments, but that they perceived many drawbacks of using *Zoom* and found that VR more closely resembled in-person interactions and provided a contextually relevant setting, suggesting that it could offer a better solution to online learning (RQ5, pp. 207-243).

Significance

This study contributed to the growing body of emerging research in the field of Computer Assisted Language Learning on how VR can benefit second language acquisition. However, it advanced this research significantly by expanding beyond solely students' perceptions and empirically evaluating how VR impacted anxiety and language performance. Moreover, this study made an important contribution to foreign language anxiety and VR research by complementing self-reported anxiety data with physiological measures of anxiety which have been absent from the field thus far. It used these physiological measures to document how anxiety fluctuated dynamically in real-time in response to learners' interactions and various factors in each learning environment. Through this approach, it filled an existing gap in research by examining peer-to-peer interpersonal second language interactions in VR. Finally, it also relied on triangulation of both quantitative and qualitative research methods in order to develop a more holistic understanding of how anxiety is impacted by virtual reality as well as to capture the voices and experiences of the learners who took part in the study.

This study also specifically explored the efficacy of VR as a language learning environment compared to a traditional classroom and *Zoom*, while accounting for the surrounding context of the COVID-19 pandemic and how it shaped students' perceptions and learning. In doing so, it examined how VR impacts learning in an ecologically valid setting, which better represents the situations that teachers will face when trying to integrate this technology into their teaching. For practitioners moving forward, this study showed that VR offers students a low-stress, realistic context in which to practice their speaking and take risks in the language which could ultimately contribute to proficiency development. Subsequently, VR, at this point, is most ideal for oral tasks and might not necessarily be beneficial for practicing other language skills like reading and writing. Finally, this study highlighted again the importance of training students to use the VR equipment to ensure that the benefits of VR are not negated by technological difficulties and frustration.

Future Directions

Moving forward, it would be beneficial to examine how anxiety fluctuates across various types of VR platforms in order to further pinpoint which elements in VR specifically contribute to or reduce anxiety. These findings could then be used to determine the ideal type of VR platform for language learning that would provide a low-stress, immersive language experience. Moreover, it would be fruitful to continue doing research that incorporates physiological measurements. Indeed, newer VR headsets allow researchers to collect data using measures like heart rate and eye tracking which could be beneficial for evaluating learners' anxiety and attention in VR settings. Finally, evaluating how VR benefits language learners' oral production and also their overall proficiency development would provide insights into the long-term benefits of using VR for language learning.

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APPENDIX A. INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

ILLINOIS

OFFICE OF THE VICE CHANCELLOR
FOR RESEARCH & INNOVATION
Office for the Protection of Research Subjects
805 W. Pennsylvania Ave., MC-095
Urbana, IL 61801-4822

Notice of Approval: Amendment #07

July 13, 2021

Principal Investigator	Aurore Mroz
CC	Tricia Thrasher
Protocol Title	*The impact of VR on anxiety and oral skills*
Protocol Number	20063
Funding Source	• University of Illinois Department of SLATE • VR@Illinois Campus Network • Duolingo Dissertation Grant in Language Learning with Technology • Language Learning Dissertation Grant
Review Type	Expedited 4, 6, 7
Amendment Requested	• Updating the research team • Adding more in-person procedures
Status	Active
Risk Determination	No more than minimal risk
Approval Date	July 13, 2021 (amendment approval date)
Closure Date	August 5, 2024

This letter authorizes the use of human subjects in the above protocol. The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) has reviewed and approved the research study as described.

The Principal Investigator of this study is responsible for:

- Conducting research in a manner consistent with the requirements of the University and federal regulations found at 45 CFR 46.
- Using the approved consent documents, with the footer, from this approved package.
- Requesting approval from the IRB prior to implementing modifications.
- Notifying OPRS of any problems involving human subjects, including unanticipated events, participant complaints, or protocol deviations.
- Notifying OPRS of the completion of the study.

APPENDIX B. PARTICIPANT CONSENT FORM

The impact of VR on anxiety and oral skills.

You are being asked to participate in a voluntary research study. The purpose of this study is to investigate how using virtual reality (VR) during language learning affects anxiety levels and oral production in French. Participating in this study will involve taking part in 8 sessions over the semester during regular class time. The first two sessions will involve filling out questionnaires with information about yourself and your experience using French. The following 6 sessions will take place in either your FR205 classroom, on Zoom or in your VR headset that will be provided to you for the duration of this course (2 sessions in each). You will participate in consensus building tasks in French during these sessions. After each session, you will fill out forms regarding how you felt during each task. At the end of the entire study, you will also be given the option to either fill out a survey or do a short interview with the researcher where you share your opinions on VR and using it in the classroom. Each session will last around approximately 50 minutes and will be integrated into your French 205 course. It is not advised to use VR technology if you have pre-existing serious medical conditions (such as a heart ailment), conditions that affect your ability to safely perform physical activities, psychiatric conditions (such as anxiety disorders or post-traumatic stress disorder), if you are pregnant or elderly, or if you are sick, as this could exacerbate your condition. However, participation in this study will allow you to practice your French oral skills and to contribute to knowledge about second language acquisition.

Principal Investigator Name and Title: Dr. Aurore Mroz, Assistant Professor
Department and Institution: Department of French & Italian, University of Illinois at Urbana-Champaign
Contact Information: apmroz@illinois.edu
Sponsor: n/a

Why am I being asked?
You are being asked to be a participant in a research study about VR and language learning. The purpose of this research is to study how VR affects anxiety levels and the consequences of this on oral production skills. You have been asked to participate in this research because you enrolled in FR205, a French oral expression course. Approximately 30 participants will be involved in this research at the University of Illinois at Urbana-Champaign.

Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future dealings with the University of Illinois at Urbana-Champaign. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

What procedures are involved?
This study takes place during your normal class time. There are 8 sessions total that will take place over the semester. During the first two sessions you will be asked to complete a brief language background questionnaire, a Foreign Language Classroom Anxiety Scale (FLCAS) questionnaire, a Social Interaction Anxiety Questionnaire, and an Immersive Tendencies Questionnaire. During the next 6 sessions, you will participate in consensus building activities in

French designed to promote discussion amongst you and two classmates. Two of these sessions will take place in the classroom, two will take place remotely in virtual reality, and two will take place remotely on Zoom. All participants will be audio-recorded and video-recorded during the completion of these activities. You will be asked to wear a heart rate monitor around your wrist during these activities. Following each activity, you will complete a short survey indicating how you felt during the activity. During the last session you will also be asked to participate in either a short interview with the researcher or respond to an open-ended questionnaire where you can give your opinion on the entire experiment and using VR in language learning.

This research will be performed in either the classroom, remotely on Zoom or remotely using your virtual reality headset. You will need to be present 8 times over the semester. Each of the sessions will last approximately 50 minutes.

What are the potential risks and discomforts?
It is not advised to use the Oculus Go VR system if you have pre-existing serious medical conditions. (such as a heart ailment), conditions that affect your ability to safely perform physical activities, psychiatric conditions (such as anxiety disorders or post-traumatic stress disorder), or if you are pregnant or elderly. Please consult a doctor to find out more. It is not advised to use VR headsets if you are sick, fatigued, under the influence of intoxicants/drugs, or are not feeling generally well, as it may exacerbate your condition. Please act accordingly.

Are there benefits to participating in the research?
This research will provide valuable data, which will contribute to knowledge about second language acquisition. It will also give you the opportunity to practice your French.

What other options are there?
You have the option to not participate in this study.

Will my study-related information be kept confidential?
Faculty, staff, students, and others with permission or authority to see your study information will maintain its confidentiality to the extent permitted and required by laws and university policies. The names or personal identifiers of participants will not be published or presented.

Will I be reimbursed for any expenses or paid for my participation in this research?
You will be given the option to participate in a post-study online 10 to 15-minute interview. If you chose to do so, you will be given a $5 Amazon gift card.

Can I withdraw or be removed from the study?
If you decide to participate, you are free to withdraw your consent and discontinue participation at any time. The researchers also have the right to stop your participation in this study without your consent if they believe it is in your best interests or you were to object to any future changes that may be made in the study plan. Your decision to decline or withdraw participation will have no effect on your grades, relationship with your instructor, or status at the University of Illinois.

Will data collected from me be used for any other research?

Your de-identified information could be used for future research without additional informed consent.

Who should I contact if I have questions?
Contact the researchers Aurore Mroz or Tricia Thrasher at apmroz@illinois.edu & tthrash2@illinois.edu if you have any questions about this study or your part in it, or if you have concerns or complaints about the research.

What are my rights as a research subject?
If you have any questions about your rights as a participant in this study, please contact the University of Illinois at Urbana-Champaign Office for the Protection of Research Subjects at 217-333-2670 or irb@illinois.edu.

I have read the above information. I have been given an opportunity to ask questions and my questions have been answered to my satisfaction. I agree to participate in this research. I will be given a copy of this signed and dated form.

______________________________ ____________
Signature Date

____
Printed Name

______________________________ ____________
Signature of Person Obtaining Consent Date (must be same as subject's)

____
Printed Name of Person Obtaining Consent

APPENDIX C. LANGUAGE BACKGROUND QUESTIONNAIRE (LBQ)

1. Please enter your UIN : ____

2. Please enter your age : ____

3. Gender: ____

4. Preferred pronouns: ____

5. Ethnicity: ____

6. Country of Origin : ____

7. Please list all the languages that you have learned (including French)
   - Language 1______________________________
   - Language 2______________________________
   - Language 3______________________________
   - Language 4______________________________
   - Language 5______________________________

8. How old were you when you started to learn ...
   - Language 1______________________________
   - Language 2______________________________
   - Language 3______________________________
   - Language 4______________________________
   - Language 5______________________________

9. Please check the French classes you have taken at UIUC.
   - ○ French101 - Elementary French I
   - ○ French102 - Elementary French II
   - ○ French 103 - Intermediate French I
   - ○ French 104 - Intermediate French II
   - ○ French 133 - Accel Intermediate French I
   - ○ French 134 - Accel Intermediate French II
   - ○ French 207 - Writing and Grammar Workshop
   - ○ French 211 - Introduction to Literary Studies
   - ○ French 212 - Introduction to Cultural Analysis: French Identities
   - ○ French 213 - French Phonetics
   - ○ French 314 - Advanced Grammar in Context
   - ○ French 322 - Movements and Perspectives
   - ○ French 335 - French Cultural History 1789 - 1968

10. How often do you use French?
- Never
- Occasionally
- Only in class and for studying purposes
- With friends and during leisure time
- As much, or more, than I use my native language

11. Have you ever had a substantial immersive experience in a French-speaking environment (study abroad of less than a semester, study abroad of more than one semester, living in a French speaking country or among a French speaking community, dual or full-immersion schooling in French?
- Yes
- No

12. If yes, what was this experience and how long was it?

____

13. How do you think technology can be used for language learning? How have you used technology for learning languages?

____

____

14. Do you have any prior experience or opinions regarding virtual reality? If so, please elaborate.

____

____

15. Have you ever been diagnosed with anxiety? If so, when?

____

16. Do you currently take any medications for anxiety?

____

17. Do you have anyways that you cope with anxiety? (i.e., yoga/exercise, drinking, painting, music, reading, etc.)

____

18. Do you have any underlying heart conditions?

____

APPENDIX D. FOREIGN LANGUAGE ANXIETY QUESTIONNAIRE (FLAQ)

The following survey will ask you questions about your language learning anxiety.

1. Please enter your UIN. ____

Part I. Please rank the following statements according to how anxious you feel regarding French in the following situations.

1 - Not at all anxious
2 - Slightly anxious
3 - Moderately anxious
4 - Extremely anxious

1. The teacher asks me a question in French in class.	1	2	3	4
2. Speaking informally in French to my French teacher outside of class.	1	2	3	4
3. Taking part in a group discussion in French in class.	1	2	3	4
4. Taking part in a role-play or dialogue in French in in front of my class.	1	2	3	4
5. When asked to contribute to a formal discussion in French class.	1	2	3	4

Part II: Please answer the following questions by providing the number that corresponds appropriately to the option that best describes your opinion.

1 - Strongly Disagree
2 - Disagree
3 - Agree
4 - Strongly Agree

6. I never feel quite sure of myself when I am speaking in my French class.	1	2	3	4
7. I don’t worry about making mistakes in French class.	1	2	3	4
8. I tremble when I know that I am going to be called on in French class.	1	2	3	4
9. It wouldn’t bother me to take more French courses.	1	2	3	4
10. I keep thinking that other students are better at French than I am.	1	2	3	4
11. I am usually at ease during oral tests in my French class.	1	2	3	4
12. I start to panic when I have to speak without preparation in French class.	1	2	3	4
13. I don’t understand why some people get so upset over foreign language classes.	1	2	3	4

14. In French class, I get so nervous that I forget things.	1	2	3	4
15. It embarrasses me to volunteer answers in French class.	1	2	3	4
16. I would not be nervous speaking French with native speakers.	1	2	3	4
17. Even if I am prepared for French class, I feel anxious about it.	1	2	3	4
18. I feel confident when I speak in French class.	1	2	3	4
19. I can feel my heart pounding when I know I am going to be called on in French class.	1	2	3	4
20. I always feel that other students speak French better than me.	1	2	3	4
21. I feel very self-conscious about speaking French in front of other students.	1	2	3	4
22. I feel more tense and nervous in French than my other classes.	1	2	3	4
23. I get nervous and confused when I am speaking in French class.	1	2	3	4
24. When I’m on my way to French class, I feel very sure and relaxed.	1	2	3	4
25. I am afraid other students will laugh at me when I speak French.	1	2	3	4
26. I would probably feel comfortable around native French speakers.	1	2	3	4
27. I feel nervous when my teacher asks questions in French that I haven’t prepared in advance.	1	2	3	4

APPENDIX E. SOCIAL INTERACTION ANXIETY SURVEY (SIAS)

(Taken from de Beurs, Tielen, & Wollmann (2014))

Instructions

In this section, for each item, please circle the number to indicate the degree to which you feel the statement is characteristic or true for you. *The rating scale is as follows:*

0	=	**Not at all** characteristic or true of me.
1	=	**Slightly** characteristic or true of me.
2	=	**Moderately** characteristic or true of me.
3	=	**Very** characteristic or true of me.
4	=	**Extremel**y characteristic or true of me

Characteristic		Not at all	Slightly	Moderately	Very	Extremely
01.	I get nervous if I have to speak with someone in authority (teacher, boss).	0	1	2	3	4
02.	I have difficulty making eye contact with others.	0	1	2	3	4
03.	I become tense if I have to talk about myself or my feelings.	0	1	2	3	4
04.	I find it difficult to mix comfortably with the people I work with.	0	1	2	3	4
05.	I find it easy to make friends my own age.	0	1	2	3	4
06.	I tense up if I meet an acquaintance in the street.	0	1	2	3	4
07.	When mixing socially, I am uncomfortable.	0	1	2	3	4
08.	I feel tense when I am alone with just one person.	0	1	2	3	4
09.	I am at ease meeting people at parties, etc.	0	1	2	3	4
10.	I have difficulty talking with other people.	0	1	2	3	4
11.	I find it easy to think of things to talk about.	0	1	2	3	4
12.	I worry about expressing myself in case I appear awkward.	0	1	2	3	4
13.	I find it difficult to disagree with another's point of view.	0	1	2	3	4
14.	I have difficulty talking to attractive persons of the opposite sex.	0	1	2	3	4

15.	I find myself worrying that I won't know what to say in social situations.	0	1	2	3	4
16.	I am nervous mixing with people I don't know well.	0	1	2	3	4
17.	I feel I'll say something embarrassing when talking.	0	1	2	3	4
18.	When mixing in a group, I find myself worrying I will be ignored.	0	1	2	3	4
19.	I am tense mixing in a group.	0	1	2	3	4
20.	I am unsure whether to greet someone I know only slightly.	0	1	2	3	4

APPENDIX F. SOCIAL PHOBIA SCALE (SPS)

(Taken from de Beurs, Tielen, & Wollmann (2014))

Instructions

In this section, for each item, please circle the number to indicate the degree to which you feel the statement is characteristic or true for you. *The rating scale is as follows:*

0	=	**Not at all** characteristic or true of me.
1	=	**Slightly** characteristic or true of me.
2	=	**Moderately** characteristic or true of me.
3	=	**Very** characteristic or true of me.
4	=	**Extremel**y characteristic or true of me

Characteristic		Not at all	Slightly	Moderately	Very	Extremel y
01.	I become anxious if I have to write in front of other people.	0	1	2	3	4
02.	I become self-conscious when using public toilets.	0	1	2	3	4
03.	I can suddenly become aware of my own voice and of others listening to me.	0	1	2	3	4
04.	I get nervous that people are staring at me as I walk down the street.	0	1	2	3	4
05.	I fear I may blush when I am with others.	0	1	2	3	4
06.	I feel self-conscious if I have to enter a room where others are already seated.	0	1	2	3	4
07.	I worry about shaking or trembling when I'm watched by other people.	0	1	2	3	4
08.	I would get tense if I had to sit facing other people on a bus or a train.	0	1	2	3	4
09.	I get panicky that others might see me faint or be sick or ill.	0	1	2	3	4
10.	I would find it difficult to drink something if in a group of people.	0	1	2	3	4
11.	It would make me feel self-conscious to eat in front of a stranger at a restaurant.	0	1	2	3	4
12.	I am worried people will think my behavior odd.	0	1	2	3	4
13.	I would get tense if I had to carry a tray across a crowded cafeteria.	0	1	2	3	4

14.	I worry I’ll lose control of myself in front of other people.	0	1	2	3	4
15.	I worry I might do something to attract the attention of other people.	0	1	2	3	4
16.	When in an elevator, I am tense if people look at me.	0	1	2	3	4
17.	I can feel conspicuous standing in a line.	0	1	2	3	4
18.	I can get tense when I speak in front of other people.	0	1	2	3	4
19.	I worry my head will shake or nod in front of others.	0	1	2	3	4
20.	I feel awkward and tense if I know people are watching me.	0	1	2	3	4

APPENDIX G. IMMERSIVE TENDENCIES QUESTIONNAIRE

1. Please give your UIN: ____

2. Indicate your preferred answer by marking the appropriate bubble of the 7-point scale.

	Never			Occasionally			Often
Do you ever get extremely involved in projects that are assigned to you by your boss or your instructor, to the exclusion of other tasks?	O	O	O	O	O	O	O
How easily can you switch your attention from the task in which you are currently involved to a new task?	O	O	O	O	O	O	O
How frequently do you get emotionally involved (angry, sad, or happy) in the news stories that you read or hear?	O	O	O	O	O	O	O
Do you easily become deeply involved in moves or TV dramas?	O	O	O	O	O	O	O
Do you ever become so involved in a television program or book that people have problems getting your attention?	O	O	O	O	O	O	O
Do you ever become so involved in a movie that you are not aware of things happening around you?	O	O	O	O	O	O	O
How frequently do you find yourself closely identifying with the characters in a story line?	O	O	O	O	O	O	O
Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?	O	O	O	O	O	O	O
When watching sports, do you ever become so involved in the game that you react as if you were one of the players?	O	O	O	O	O	O	O
Do you ever become so involved in a daydream that you are not aware of things happening around you?	O	O	O	O	O	O	O
Do you ever have dreams that are so real that you feel disoriented when you awake?	O	O	O	O	O	O	O
When playing sports, do you become so involved in the game that you lose track of time?	O	O	O	O	O	O	O

Are you easily disturbed when working on a task?	O	O	O	O	O	O	O
How often do you play arcade or video games? (Often should be taken to mean every day or every two days, on average.)	O	O	O	O	O	O	O
Have you ever gotten excited during a chase or fight scene on TV or in the movies?	O	O	O	O	O	O	O
Have you ever gotten scared by something happening on a TV show or in a movie?	O	O	O	O	O	O	O
Have you ever remained apprehensive or fearful long after watching a scary moving?	O	O	O	O	O	O	O
Do you avoid carnival or fairground rides because they are too scary?	O	O	O	O	O	O	O
How frequently do you watch TV soap operas or docu-dramas?	O	O	O	O	O	O	O
Do you ever become so involved in doing something that you lose all track of time?	O	O	O	O	O	O	O

3. Indicate your preferred answer by marking the appropriate bubble of the 7-point scale.

	Not at all			Moderately Well			Very Well
How well do you concentrate on disagreeable tasks?	O	O	O	O	O	O	O
How well do you concentrate on enjoyable activities?	O	O	O	O	O	O	O

4. Indicate your preferred answer by marking the appropriate bubble of the 7-point scale.

	Not at all			Some			Entirely
To what extent have you dwelled on personal problems in the last 48 hours?	O	O	O	O	O	O	O

5. Indicate your preferred answer by marking the appropriate bubble of the 7-point scale.

	Not very good			Somewhat good			Very Good
How good are you at blocking out external distractions when you are involved in something?	O	O	O	O	O	O	O
How do you feel today?	O	O	O	O	O	O	O

6. Indicate your preferred answer by marking the appropriate bubble of the 7-point scale.

	Not alert			Moderately			Very alert
How mentally alert do you feel at the present time?	O	O	O	O	O	O	O

7. What kind of books do you read? (Select only one)

- Spy
- Adventure
- Westerns
- Bibliographies
- Fantasies
- Romance
- Mysteries
- Autobiographies
- Science Fiction
- Historical
- Other

APPENDIX H. FRENCH 205 COURSE SYLLABUS COVID-19 POLICIES

3. REQUIRED MATERIALS

For on-campus sessions:
This course's Wednesday sessions will take place on campus, in 1027 Lincoln Hall, until November 20. **After November 20, all sessions will be exclusively online**. Due to the covid-19 situation, and in accordance with UIUC guidelines and policies, students will be required to get tested ahead of coming on campus, and to come on campus with a mask. In addition, students will also be required to purchase a face-shield to bring with them to class, to be able to communicate safely with each other without the obstacle of the mask (e.g., https://www.amazon.com/Fulfillment-Sunzel-Shields-Sponges-Protect/dp/B08D3FWKLP/ref=sr_1_6?dchild=1&keywords=face+shields&qid=1597181241&sr=8-6). Note that you will not be allowed to come on campus simply wearing a face shield. You will need **both a mask** (to enter campus) **and a face-shield** (to talk in class).

All the texts needed for this course will be posted by your instructor on Moodle (https://learn.illinois.edu/). Note that no electronic device will be allowed in class, so **you must print out all the texts and bring them to class**. You should also bring a notebook and a pen to face-to-face classes on Wednesdays.

For online sessions :
Students are required to have a working computer and a reliable internet connection allowing them to access Moodle and Zoom. It is also strongly recommended that students invest into a quality headset (earphones + microphone) to enhance all oral communication: simply counting on the computer's internal speakers and microphone might lead to poor audio quality.

Some course sessions will also take place in a Virtual Reality format. For that purpose, students will be loaned 1 Oculus Go VR headset (headset, controller, and charger) and 1 Polar OH1 heart rate monitor for the duration of the semester. **This equipment is property of the University of Illinois.** Students may use this equipment for class purposes and in their free time. However, they may **not** loan or sell any of the equipment. Students will be required to return all equipment **in the same condition that it was received by November 20th**, or the last day of in-person Fall 2021 instruction.

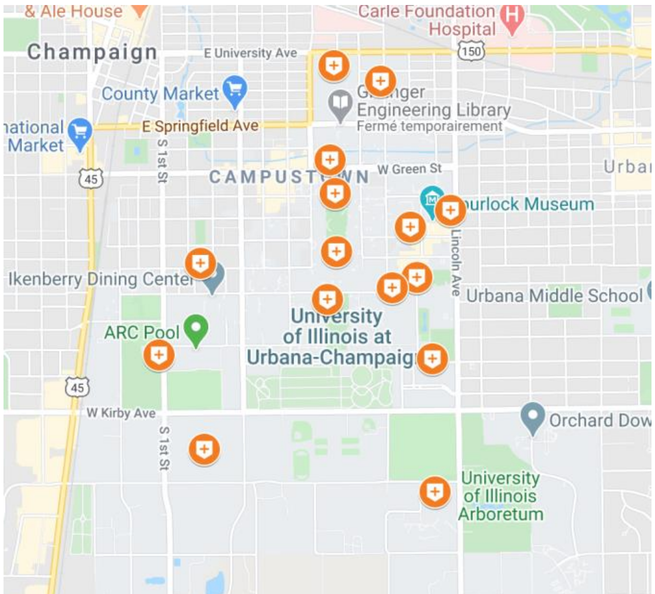
4. COVID-19 REGULATIONS AND PROCEDURE

- Students will not be allowed to enter University classrooms or buildings if:
  - they have tested positive for COVID-19
  - they have missed a mandatory test
  - they are currently awaiting a test result after notification of exposure
  - they are not wearing a face covering (https://covid19.illinois.edu/health-and-support/face-coverings/#facecovering)
- Students must provide proof of compliance with testing requirements prior to entering a classroom. A Wellness Support Associate will be stationed at the classroom or building entrance checking status before students enter class. Students will show the Associate their status in the "**Safer in Illinois**" app or through an alternative method (https://safer.illinois.edu/)
- We recommend that all students, faculty and staff utilize the "Safer in Illinois" app for COVID-19 testing, notification and status (https://safer.illinois.edu/)
- **In order to attend Wednesday sessions on campus, students will need to be tested for covid:**
  - **no earlier than the Sunday morning prior to the on-campus class**
  - **no later than the Monday evening prior to the on-campus class**
- No loss of point or penalty of any kind will be applied to your grade if you need to miss class, whether online or on-campus, due to a covid-related issue documented by the university. These covid-related absences will also NOT count towards the 2 absences authorized during the semester.
- For more information about procedures related to covid-19, please refer to https://covid19.illinois.edu/covid-19-classroom-management-info/

Please see https://covid19.illinois.edu/health-and-support/on-campus-covid-19-testing-locations/

- Make sure you bring your iCard. **You will need to show a *current* i-card.**
- You should refrain from eating, drinking, tooth brushing, mouth washing, gum chewing, and tobacco use for 30 minutes before submitting your saliva sample.
- While you line up outside the testing location, you should wear a face covering and practice social distancing.

Where can I get tested for COVID-19?



On-Campus Testing Locations

- Alice Campbell Alumni Center
- Foellinger Auditorium Forecourt Tent
- Beckman Institute
- Campus Recreation Center East (CRCE)
- Freer Hall
- Graziano Plaza
- Illini Grove
- Illini Union
- Krannert Center for the Performing Arts
- Lot 31
- NCSA
- South Quad
- State Farm Center
- Veterinary Medicine Tent
- Washington Park

APPENDIX I. CONSENSUS BUILDING TASKS

Theme 1: Trends & The Youth

Une Nouvelle Série YouTube

Utiliser votre rôle pour guider votre discussion :

Rôle 1 : Le nouvel employé
Vous venez d'être embauché* (hired) par *Roxane*, une agence spécialiste des réseaux sociaux à Paris. Votre premier projet ? Travailler avec votre patron et un collègue plus avancé que vous pour créer une nouvelle série YouTube. Le problème ? Votre patron est vraiment sévère et n'aime pas les choses trop créatives. Mais, vous avez une vision spécifique en tête pour la série et vous croyez savoir ce qui intéresse les jeunes. Votre idée : Faire une série sur la cuisine végane… c'est vraiment à la mode en ce moment.

Vous avez une réunion au bar avec votre patron et collègue. Travaillez ensemble et essayez de trouver un thème pour la série qui vous plait à tous. (20 minutes)

À considérer : le thème, des détails spécifiques (combien d'épisodes, où ils seront enregistrés), les aspects financiers, un titre, etc.

Rôle 2 : Le patron

Vous êtes le patron d'une agence spécialiste des réseaux sociaux à Paris, *Roxane*. Aujourd'hui, vous avez une réunion avec un collègue et un nouvel employé pour trouver le sujet d'une nouvelle série YouTube que vous voudriez créer. Le problème ? Vous voudriez faire quelque chose de classique, mais vous savez que les deux autres voudront faire quelque chose de branché (*trendy*). Votre idée : faire une série qui met en avant certains restaurants français traditionnels à Paris.

Vous avez une réunion au bar avec vos deux collègues. Travaillez ensemble et essayez de trouver un thème pour la série qui vous plait à tous. (20 minutes)

À considérer : le thème, des détails spécifiques (combien d'épisodes, où ils seront enregistrés), les aspects financiers, un titre, etc.

Rôle 3 : L'employé plus avancé

Ça fait un an que vous travaillez à Roxane, une agence spécialiste des réseaux sociaux à Paris. Aujourd'hui, vous avez une réunion avec votre patron et un nouvel employé pour trouver le sujet d'une nouvelle série YouTube que votre patron voudrait créer. Le problème ? Votre patron est vraiment sévère et n'aime pas les choses trop créatives. De plus, vous n'aimez pas le nouvel employé. Votre idée : Vous aimez bien voyager et vous voulez utiliser cette série comme excuse pour voyager plus! Pour vous, une série qui explore de nouvelles destinations de voyage serait idéale.

Vous avez une réunion au bar avec votre patron et collègue. Travaillez ensemble et essayez de trouver un thème pour la série qui vous plait à tous. (20 minutes)

À considérer : le thème, des détails spécifiques (combien d'épisodes, où ils seront enregistrés), les aspects financiers, un titre, etc.

Theme 2: Science and Technology

Introduction

La technologie devient de plus en plus avancée, efficace et complexe. Aujourd'hui, il y a la réalité virtuelle et augmentée, l'intelligence artificielle, les bots informatiques, etc. Avec ce progrès scientifique, les scientifiques continuent de développer des technologies plus avancées qui peuvent nous aider à améliorer notre société et notre vie quotidienne.

Cependant, même si ces nouvelles technologies peuvent être très utiles pour notre société, il existe quand même des risques. (par exemple : est-ce que l'intelligence artificielle devient trop avancée ? est-ce que les robots pensent vraiment ? est-ce que nos données sont privées ? etc.)

Votre tâche :

Etape 1 *: Avec votre groupe, discutez et notez* ***3 bénéfices*** *(ainsi que* ***3 risques****) de la technologie. Par exemple : comment est-ce que la technologie peut aider (ou faire du mal à) notre société ?* **(~5 minutes)**

Etape 2 : *Travaillez ensemble et* ***trouvez un problème*** *dans la société que vous souhaitez résoudre. Ensuite,* ***imaginez une nouvelle invention technologique*** *qui résoudra ce problème (Que fera-t-elle ? Quel problème va-t-elle résoudre ? Comment sera-t-elle utilisée dans la société ? Y-a-t-il des risques ?)* **(~15 minutes)**

Utiliser votre rôle pour guider votre discussion :

Rôle 1 : Vous êtes doctorant(e) en ingénierie à l'Université de Sorbonne et vous collaborez avec votre professeur sur un projet de recherche mené par la plus grande société de développement technologique à Paris. Aujourd'hui, vous avez une réunion avec votre professeur et le PDG de l'entreprise pour parler d'une nouvelle technologie que vous pourriez créer.

Rôle 2 : Vous êtes PDG de la plus grande société de développement technologique à Paris. Cette année, vous voudriez commencer un nouveau projet pour créer une nouvelle technologie qui aidera la société. Aujourd'hui, vous avez une réunion avec un professeur d'ingénierie et un doctorant qui travaille avec lui pour parler d'une nouvelle technologie que vous pourriez créer.

Rôle 3 : Vous êtes professeur d'ingénierie à l'université de Sorbonne. Votre recherche se porte principalement sur les technologies qui peuvent être utiles pour la société. Aujourd'hui, vous avez une réunion avec le PDG de la plus grande société de développement technologique à Paris et un doctorant qui travaille avec vous pour parler d'une nouvelle technologie que vous pourriez créer.

Theme 3: Ecology and the Environment

Introduction :

On parle de plus en plus de protection de l'environnement. En quoi sommes-nous concernés ? Quel impact cela a-t-il sur notre quotidien ?

Protéger l'environnement, c'est préserver la survie et l'avenir de l'humanité. En effet, l'environnement est notre source de nourriture et d'eau potable. L'air est notre source d'oxygène. Le climat permet notre survie. Et la biodiversité est un réservoir potentiel de médicaments. Préserver l'environnement est donc une question de survie.

Mais à l'allure où vont les choses, nous allons bientôt détruire la planète. Heureusement, nous pouvons tout de même faire des efforts rapides et efficaces pour tenter de la préserver. Cependant, certaines personnes veulent sauver la planète mais ne savent pas quoi faire. Votre tâche aujourd'hui ? Travaillez avec votre groupe et organisez un atelier d'écologie qui apprendra aux habitants de Champaign comment protéger l'environnement.

Votre tâche :

Étape 1 (2 à 3 minutes) : *Parlez avec votre groupe et notez 3 raisons pour lesquelles il est absolument nécessaire de protéger l'environnement.*

Étape 2 (5 à 7 minutes) : *Parlez ensemble et notez 5 façons pratiques dont les habitants de Champaign peuvent protéger l'environnement.*

Étape 3 (10 à 12 minutes) : *Imaginez un atelier que vous pourriez organiser qui apprendrait aux habitants de Champaign comment protéger l'environnement. Comment pourriez-vous les convaincre d'adopter des habitudes écolos et vivre une vie plus durable ? Quels conseils concrets pourriez-vous leur donner ?*

Utiliser votre rôle pour guider votre discussion :

Rôle 1 : Vous êtes le Directeur / la Directrice de *Champaign County Sustainability Network.* Vous imaginez organiser un atelier qui apprendra aux habitants comment économiser l'eau et l'énergie. Vous pensez qu'il est également important que les habitants réduisent la pollution mais que les convaincre d'économiser de l'énergie sera plus simple.

Rôle 2 : En tant qu'étudiant(e) en écologie, vous croyez que la pollution est le problème le plus menaçant pour l'avenir de la planète. En plus, vous croyez que les participants de l'atelier sauront déjà économiser l'eau et l'énergie. Vous souhaitez donc organiser un atelier qui apprendra aux habitants comment réduire la pollution et leur empreinte écologique.

Rôle 3 : Vous êtes un bénévole qui s'intéresse à la durabilité. Vous souhaitez donc organiser un atelier où vous pourrez apprendre aux gens à vivre une vie plus durable comme vous (par exemple : éviter le gaspillage, acheter moins, etc.) !

Thème 4 : Education

Introduction :

Le système scolaire a beaucoup de problèmes en ce moment. Malheureusement, votre lycée est en crise financière et, du coup il y a des coupes budgétaires. Dans un effort pour trouver une solution, une réunion va avoir lieu avec le directeur du lycée, l'un des enseignants principaux et le représentant des étudiants. Votre tâche : discutez avec les membres de votre groupe pour décider où vous pouvez réduire vos dépenses. Après avoir discuté, présentez votre solution à la classe.

<u>Utiliser votre rôle pour guider votre discussion :</u>

Rôle 1 : Le directeur de l'école
Vous avez quelques idées sur la manière de réduire vos dépenses.

1. Eliminer la technologie qui est dans les salles de classe ?
2. Augmenter le nombre d'étudiants dans chaque classe ?
3. Réduire les activités extrascolaires ?
4. Réduire le nombre de bourses que le lycée offre aux étudiants.

Cependant, vous ne savez pas quoi faire. Vous voudriez discuter avec l'un des professeurs de l'école et le représentant d'étudiant pour avoir leurs opinions.

Rôle 2 : L'un des enseignants du lycée
Pour vous, augmenter le nombre d'étudiants dans chaque classe n'est pas du tout possible. Il y a déjà trop d'étudiants par classe et il est trop difficile d'enseigner. En plus, faire cela réduit la qualité de l'enseignement pour les étudiants parce qu'il est plus difficile de leur donner des réactions individuelles. En plus, vous préférez ne pas réduire le nombre de bourses que le lycée offre aux étudiants parce que cela permet aux étudiants qui n'ont pas beaucoup d'argent de venir au lycée.

Pour vous, la meilleure option, c'est d'éliminer la technologie qui est dans les salles de classes. Sans formation, la technologie qui coûte souvent chère est très difficile à utiliser pour les enseignants et elle peut être distrayante pour les étudiants.

Rôle 3 : Le représentant d'étudiant
Pour vous, éliminer la technologie qui est dans les salles de classe n'est pas une bonne idée. Les étudiants sont jeunes et ils sont habitués à utiliser la technologie. En plus, des études montrent que les étudiants, surtout ceux qui font partie de la Génération Z, apprennent mieux en utilisant la technologie parce qu'ils sont plus intéressés.
En plus, vous préférez ne pas réduire les activités extrascolaires parce que vous pensez qu'elles sont bonnes pour la santé mentale des étudiants. Pour vous, la meilleure option, c'est augmenter le nombre d'étudiants dans chaque classe. Si les enseignants utilisent plus de technologie, ils pourront enseigner à plus d'étudiants en même temps.

Theme 5 : Media

Introduction

Les réseaux sociaux ont un grand impact sur notre vie quotidienne. Qu'ils soient sur invitation, réservés aux professionnels ou ouverts à tous, les réseaux sociaux et les blogs prennent de plus en plus de place dans notre vie. Avec des millions d'adeptes - Facebook compterait plus de 2.13 milliards d'usagés mensuels -, ils s'imposent comme outils de communication et de changement. Bien sûr, les réseaux sociaux offrent des avantages à ceux qui s'y inscrivent, mais aussi quelques inconvénients.

Votre tâche :

Vous travaillez pour Facebook et vous essayez de créer un nouveau réseau social pour les jeunes. Aujourd'hui vous avez une réunion avec vos collègues pour discuter des avantages et des dangers des médias sociaux et pour essayer de trouver une idée pour votre nouveau réseau.

À considérer : que pourront faire les jeunes sur le réseau social ? comment créer un réseau qui est utile mais pas addictif ? comment ce nouveau réseau est-il différent des autres ? un nom pour votre réseau ? etc.

Utiliser votre rôle pour guider votre discussion :

Rôle 1 : Vous êtes Mark Zuckerberg, le fondateur de Facebook. Vous souhaitez créer un nouveau réseau social qui séduit les jeunes afin qu'ils l'utilisent constamment. Vous ne vous souciez pas des dangers des médias sociaux. Le plus important pour vous est de gagner de l'argent.

Rôle 2 : Vous travaillez chez Facebook comme concepteur d'applications mobiles depuis 6 ans. Vous souhaitez créer un nouveau réseau social pour les jeunes qui soit super pratique et facile à utiliser et qui les relie de manière significative.

Rôle 3 : Vous êtes stagiaire chez Facebook depuis un an. Vous souhaitez créer un nouveau réseau pour les jeunes, mais vous vous inquiétez des dangers des réseaux sociaux. Vous souhaitez créer un réseau qui ne soit pas trop addictif.

Theme 6a : Sports and Hobbies

Introduction :

Le 26 juillet 2024 s'ouvriront les XXXIIIe Jeux olympiques (JO) d'été à Paris. Cent ans après la précédente édition dans la Ville lumière. Et seulement trois ans après ceux de Tokyo puisque, pour la première fois de l'histoire, une édition a été reportée d'un an en raison de la crise sanitaire liée à la pandémie de Covid-19.

La capitale doit maintenant s'atteler à la préparation de l'événement dans 3 ans, mais avec les crises économiques et sanitaires liées à la pandémie de Covid-19, comment tout cela va-t-il se passer ?

Votre tâche : Avec votre groupe, essayez d'organiser les JO de 2024 en pensant aux questions suivantes :

1) Pourquoi les JO sont-ils importants ? Que représentent-ils ?

2) Quel sera le budget des JO ? Comment pourriez-vous réduire le coût de l'événement ? Combien coûteront les billets ? Est-ce que les JO sont en fait une chance économique qui pourrait aider la crise financière ?

3) Quels sports y aura-t-il ? Est-il possible d'éliminer un sport pour aider les situations financières ou sanitaires ?

4) Où seront les JO ? Est-ce que tout se passera à Paris ? Ou est-ce mieux d'avoir quelques événements ailleurs ?

5) Comment assurer la santé de tout le monde en faisant attention également à la crise financière ? Est-ce mieux d'annuler les JO ? De les reporter à plus tard ? De limiter le nombre de gens qui peuvent venir ?

Utilisez votre rôle pour guider votre discussion.

Rôle 1 : Vous êtes président du comité d'organisation à Paris pour les JO de 2024. Vous avez une réunion aujourd'hui avec deux autres membres du comité -- le vice-président et le trésorier -- pour parler des JO. Avec la crise sanitaire, vous voudriez absolument adopter les mesures pour assurer la santé de tous au cas où il y aurait une autre pandémie mondiale.

Rôle 2 : Vous êtes vice-président du comité d'organisation à Paris pour les JO de 2024. Vous avez une réunion aujourd'hui avec deux autres membres du comité -- le président et le trésorier -- pour parler des JO. Avec la crise financière, vous essayez d'organiser l'événement en faisant attention au coût global. Vous ne vous inquiétez pas vraiment de la crise sanitaire parce que vous pensez que cela ne sera plus un problème en 2024.

Rôle 3 : Vous êtes trésorier du comité d'organisation à Paris pour les JO de 2024. Vous avez une réunion aujourd'hui avec deux autres membres du comité -- le président et le vice-président -- pour parler des JO. Avec la crise financière en France, vous ne voyez pas comment vous pouvez continuer à préparer les JO de Paris. Pour vous, il est mieux d'annuler les JO de 2024, surtout parce que les JO de Tokyo ont été déjà reportés d'un an.

Theme 6b : Art and Culture

Introduction :
Malgré la pandémie et la mise en place d'un troisième confinement en France jusqu'à début mai, le Festival de Cannes est maintenu : il devrait se dérouler du 6 au 17 juillet 2021. Le festival sera forcément chamboulé par les règles sanitaires imposées par le Covid-19. Même si la situation reste incertaine, les organisateurs sont bien décidés à préparer les festivités, afin que le Festival se déroule (presque) normalement, et en présentiel. Car le but est d'éviter une remise de prix virtuelle, voire pire ; l'annulation du festival, comme cela a été le cas en 2020. C'est d'ailleurs aussi la raison pour laquelle les dates de cette année ont été modifiées ; initialement le festival devait avoir lieu, comme chaque année, en mai. La ville de Cannes doit maintenant s'atteler à la préparation de l'événement, mais avec les crises économiques et sanitaires liées à la pandémie, comment tout cela va-t-il se passer ?

Votre tâche : Avec votre groupe, essayez d'organiser le Festival de Cannes en pensant aux questions suivantes :

1) Pourquoi le festival est-il important ? Que représente-t-il ?

2) Quel sera le budget du festival ? Comment pourriez-vous réduire le coût de l'événement ? Combien coûteront les billets ? Est-ce que le festival est en fait une chance économique pour la crise financière ?

3) Quels acteurs/studios viendront ? ? Est-il possible d'avoir moins de personnes pour aider la situation sanitaire ?

4) Où sera le festival ? Est-ce que tout se passera à Cannes ? Ou est-ce mieux d'avoir quelques événements ailleurs ?

5) Comment assurer la santé de tout le monde en faisant attention également à la crise financière ? Est-ce mieux d'annuler le festival ? De le reporter à plus tard ? De limiter le nombre de gens qui peuvent venir ?

Utilisez votre rôle pour guider votre discussion.

Rôle 1 : Vous êtes président du comité d'organisation pour le Festival de Cannes. Vous avez une réunion aujourd'hui avec deux autres membres du comité -- le vice-président et le trésorier -- pour parler du festival. Avec la crise sanitaire, vous voudriez absolument adopter les mesures pour assurer la santé de tous les gens qui viennent au festival cet été.

Rôle 2 : Vous êtes vice-président du comité d'organisation pour le Festival de Cannes. Vous avez une réunion aujourd'hui avec deux autres membres du comité -- le président et le trésorier -- pour parler du festival. Avec la crise financière, vous essayez d'organiser l'événement en faisant attention au coût global. Vous ne vous inquiétez pas vraiment de la crise sanitaire parce que vous pensez que la plupart des gens seront vaccinés avant le festival.

Rôle 3 : Vous êtes trésorier du comité d'organisation pour le Festival de Cannes. Vous avez une réunion aujourd'hui avec deux autres membres du comité -- le président et le vice-président -- pour parler du festival. Avec le nouveau confinement en France, vous ne voyez pas comment vous pouvez continuer à préparer le festival. Pour vous, il est mieux de reporter le festival à l'année prochaine.

APPENDIX J. POST CR ACTIVITIES QUESTIONNAIRE

1. Please enter your UIN. ____

Please answer the following questions by providing the number corresponding to the option that best describes your opinion.

1 - Strongly Disagree
2 - Somewhat Disagree
3 - Somewhat Agree
4 - Strongly Agree

2. I felt at ease when completing this activity.	1	2	3	4
3. I didn't worry about making mistakes during this activity.	1	2	3	4
4. I didn't feel very sure of myself during this activity.	1	2	3	4
5. It wouldn't bother me to do more activities like this.	1	2	3	4
6. During this activity, I was so nervous that I forgot things.	1	2	3	4
7. I felt confident during this activity.	1	2	3	4
8. I felt self-conscious about speaking French during this activity.	1	2	3	4
9. I was nervous about performing in front of the researcher during this activity.	1	2	3	4
10. I was nervous about being recorded during this activity.	1	2	3	4
11. I was more nervous during this activity than during normal class time.	1	2	3	4
12. I felt free to make mistakes during this activity.	1	2	3	4

13. How immersed in a French speaking environment did you feel during this activity compared to normal class time?

1 - Way less immersed
2 - Somewhat less immersed
3 - The same
4 - Somewhat more immersed
5 - Way more immersed

14. How useful do you think this activity was for you compared to activities you do in daily French class?

1 - A lot less useful
2 - Slightly less useful
3 - The same
4 - Slightly more useful
5 - Way more useful

15. Did the role that you played in the conversation influence how you interacted with your peers? How so?

16. Did the role that you played in the conversation impact your anxiety? How so?

17. In the past two weeks, how many times (estimate) have you used your VR headset outside of class time? For roughly how long each time?

APPENDIX K. POST ZOOM ACTIVITIES QUESTIONNAIRE

1. Please enter your UIN. ____

Please answer the following questions by providing the number corresponding to the option that best describes your opinion.

1 - Strongly Disagree
2 - Somewhat Disagree
3 - Somewhat Agree
4 - Strongly Agree

2. I felt at ease when completing this activity.	1	2	3	4
3. I didn't worry about making mistakes during this activity.	1	2	3	4
4. I didn't feel very sure of myself during this activity.	1	2	3	4
5. It wouldn't bother me to do more activities like this.	1	2	3	4
6. During this activity, I was so nervous that I forgot things.	1	2	3	4
7. I felt confident during this activity.	1	2	3	4
8. I felt self-conscious about speaking French during this activity.	1	2	3	4
9. I was nervous about performing in front of the researcher during this activity.	1	2	3	4
10. I was nervous about being recorded during this activity.	1	2	3	4
11. I was more nervous during this activity than during normal class time.	1	2	3	4
12. I felt free to make mistakes during this activity.	1	2	3	4

13. How immersed in a French speaking environment did you feel during this activity compared to normal class time?

1 - Way less immersed
2 - Somewhat less immersed
3 - The same
4 - Somewhat more immersed
5 - Way more immersed

14. How useful do you think this activity was for you compared to activities you do in daily French class?

1 - A lot less useful
2 - Slightly less useful
3 - The same
4 - Slightly more useful
5 - Way more useful

15. Did the role that you played in the conversation influence how you interacted with your peers? How so?

16. Did the role that you played in the conversation impact your anxiety? How so?

17. In the past two weeks, how many times (estimate) have you used your VR headset outside of class time? For roughly how long each time?

APPENDIX L. POST VR ACTIVITIES QUESTIONNAIRE

1. Please enter your UIN. ____

Please answer the following questions by providing the number corresponding to the option that best describes your opinion.

1 - Strongly Disagree
2 - Somewhat Disagree
3 - Somewhat Agree
4 - Strongly Agree

2. I felt at ease when completing this activity.	1	2	3	4
3. I didn't worry about making mistakes during this activity.	1	2	3	4
4. I didn't feel very sure of myself during this activity.	1	2	3	4
5. It wouldn't bother me to do more activities like this.	1	2	3	4
6. During this activity, I was so nervous that I forgot things.	1	2	3	4
7. I felt confident during this activity.	1	2	3	4
8. I felt self-conscious about speaking French during this activity.	1	2	3	4
9. I was nervous about performing in front of the researcher during this activity.	1	2	3	4
10. I was nervous about being recorded during this activity.	1	2	3	4
11. I was more nervous during this activity than during normal class time.	1	2	3	4
12. I felt free to make mistakes during this activity.	1	2	3	4

13. How immersed in a French speaking environment did you feel during this activity compared to normal class time?

1 - Way less immersed
2 - Somewhat less immersed
3 - The same
4 - Somewhat more immersed
5 - Way more immersed

14. How useful do you think this activity was for you compared to activities you do in daily French class?

1 - A lot less useful
2 - Slightly less useful
3 - The same
4 - Slightly more useful
5 - Way more useful

18. Please select the response that you most agree with.

- During this activity, I felt as if I was in the environment.
- During this activity, I felt as if I saw images of the environment without feeling like I was inside it.

19. Please select the response that you most agree with.

- During this activity, it was as if the other students were with me.
- During this activity, it was as if I was alone.

20. Please select the response that you most agree with.

- o During this activity, it was as if the other students were looking at me.
- o During this activity, it was as if no one was paying attention to me.

21. Please select the response that you most agree with.

- o During this activity, I made sure to not bump into objects in the environment.
- o During this activity, I moved without paying attention to the surrounding objects.

22. Please select the response that you most agree with.

- o During this activity, my hands moved as expected when I moved them.
- o During this activity, I was surprised by how my hands moved when moving them.

23. Please select the response that you most agree with.

- o During this activity, the other students' voices were clear and easy to hear and understand.
- o During this activity, the other students' voices were not clear and were not easy to hear or understand.

24. Please select the response that you most agree with.

- o During this activity, the objects in the environment were clear and easy to see.
- o During this activity, the objects in the environment were not clear and not easy to see.

25. Please select the response that you most agree with.

- o During this activity, I spent more time actively participating.
- o During this activity, I spent more time observing others.

26. Please select the response that you most agree with.

- o During this activity, I quickly adjusted to the virtual environment.
- o During this activity, I did NOT quickly adjust to the virtual environment.

27. Please select the response that you most agree with.

- o During this activity, my senses were engaged.
- o During this activity, my senses were NOT engaged.

25. Please select the response that you most agree with.

- o During this activity, the information provided through different senses (vision, hearing) were consistent.
- o During this activity, the information provided through different senses (vision, hearing) were NOT consistent.

26. Please select the response that you most agree with.

- o During this activity, the visual display did NOT interfere or distract me from performing the assigned task.
- o During this activity, I did interfere or distract me from performing the assigned task.
- o

15. Did the role that you played in the conversation influence how you interacted with your peers? How so?

16. Did the role that you played in the conversation impact your anxiety? How so?

17. In the past two weeks, how many times (estimate) have you used your VR headset outside of class time? For roughly how long each time?

APPENDIX M. QUALITATIVE DEBRIEFING QUESTIONNAIRE

1. What is your UIN? ____

2. Did you have a preference regarding the 6 activities that you did with Tricia (i.e. either in the classroom, virtual reality (VR) or Zoom)? Why or why not?

____

3. Do you feel like you were more successful during any of the 6 activities? Why or why not?

____

4. Did you find yourself speaking more than usual during any of the 6 activities? If so, why do you think that is?

____

5. Did you feel more at ease/relaxed during any of the 6 activities? If so, why do you think that is?

____

6. What were your first impressions working with VR? What did you enjoy (if anything) and what would you like to change (if anything)?

____

7. Were you comfortable using the VR technology?

____

8. Did using VR impact how you feel about learning French? How so?.

____

9. Did you ever use VR during your free time outside of class? If so, what types of things would you use it for? (e.g., games, videos, etc.)

____

10. Did you find the VR environments to be immersive? Why or why not?

____

11. Did you ever forget that you were in VR when using it? If so, please elaborate.

____

12. Could you describe the feeling you had when coming out of the VR headset and back to reality?

____

13. Did you notice any changes in your anxiety across the 6 activities? If so, what changes did you notice and why do you think they occurred?

____

14. Did any of the 6 activities make you uncomfortable or self-conscious? If so, which ones and why?

____

15. Did the presence of your group members, your teacher, or the researcher impact how comfortable you felt during any of the exercises? If so, please elaborate.

____

16. Did being represented by an avatar impact how your felt during the VR activities? If so, how?

____

17. Did being represented by an avatar contribute to how immersed you felt in the VR?

____

18. Please include any additional comments you may have.

____

APPENDIX N. R-CODE

Dissertation

Thrasher

9/29/2020

```
#Loading packages
require(ggplot2)

## Loading required package: ggplot2

require(dplyr)

## Loading required package: dplyr

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

require(factoextra)

## Loading required package: factoextra

## Welcome! Want to learn more? See two factoextra-related books at ht
tps://goo.gl/ve3WBa

require(emmeans)

## Loading required package: emmeans

require(EMAtools)

## Loading required package: EMAtools

require(lmerTest)

## Loading required package: lmerTest

## Loading required package: lme4

## Loading required package: Matrix
```

```
##
## Attaching package: 'lmerTest'

## The following object is masked from 'package:lme4':
##
##     lmer

## The following object is masked from 'package:stats':
##
##     step

require(lme4)
require(psych)

## Loading required package: psych

## Warning: package 'psych' was built under R version 4.1.2

##
## Attaching package: 'psych'

## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha

require(effectsize)

## Loading required package: effectsize

##
## Attaching package: 'effectsize'

## The following object is masked from 'package:psych':
##
##     phi

#Looking at LBQ data for methodology section of the article
library(readxl)
LBQData <- read_excel("dissertation_data.xlsx",
    sheet = "LBQData")
LBQData$Age = as.numeric(LBQData$Age)
mean(LBQData$Age)

## [1] 20.15789

min(LBQData$Age)

## [1] 18

max(LBQData$Age)
```

```
## [1] 32
```

```
LBQData$OnsetFrench = as.numeric(LBQData$OnsetFrench)
mean(LBQData$OnsetFrench)
```

```
## [1] NA
```

```
min(LBQData$OnsetFrench)
```

```
## [1] NA
```

```
max(LBQData$OnsetFrench)
```

```
## [1] NA
```

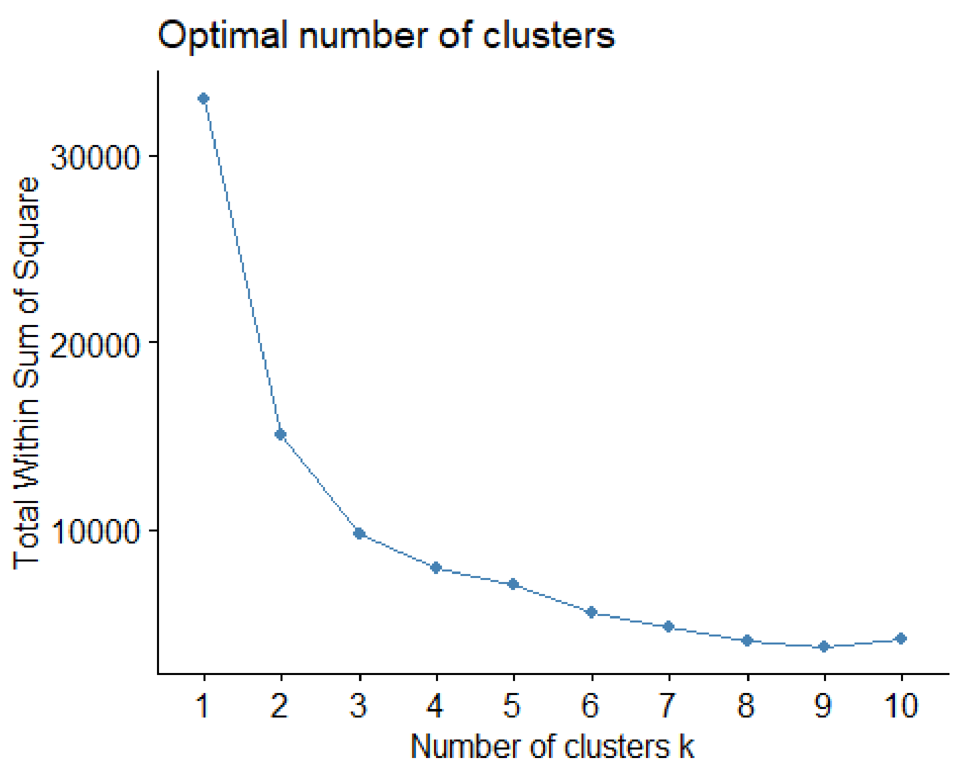
```
require(dplyr)
HighAnx = LBQData %>% filter(AnxietyGroup == "ANX+")
```

```
#Coming up with participant groups based on their background informati
on:
#using kmeans to divide participants into different groups based on FL
AQ, SIAS, SPS
colnames(LBQData)
```

```
##  [1] "Participant"
##  [2] "Name"
##  [3] "UIN"
##  [4] "Age"
##  [5] "Gender"
##  [6] "Pronouns"
##  [7] "Ethnicity"
##  [8] "HomeCountry"
##  [9] "LL1"
## [10] "LL2"
## [11] "LL3"
## [12] "LL4"
## [13] "LL5"
## [14] "OnsetFrench"
## [15] "Multilingual"
## [16] "AgeLL1"
## [17] "AgeLL2"
## [18] "AgeLL3"
## [19] "AgeLL4"
## [20] "AgeLL5"
## [21] "FrenchCourses"
## [22] "UseFrench"
## [23] "SubstantialImmersion"
## [24] "Details"
```

```
## [25] "How do you think technology can be used for language learning
? How have you used technology for learning languages?"
## [26] "Do you have any prior experience or opinions regarding virtua
l reality? If so, please elaborate."
## [27] "Have you ever been diagnosed with anxiety? If so, when?"
## [28] "AnxietyDiagnosis"
## [29] "Do you currently take any medications for anxiety?"
## [30] "Do you have anyways that you cope with anxiety? (i.e., yoga/e
xercise, drinking, painting, music, reading, etc.)"
## [31] "Underlying heart conditions?"
## [32] "BaseAnx"
## [33] "AnxietyGroup"
## [34] "Part.Group"
## [35] "SIAS"
## [36] "SPS"
## [37] "ITQFocus"
## [38] "ITQInvolve"
## [39] "ITQGames"
## [40] "ITQTotal"
```

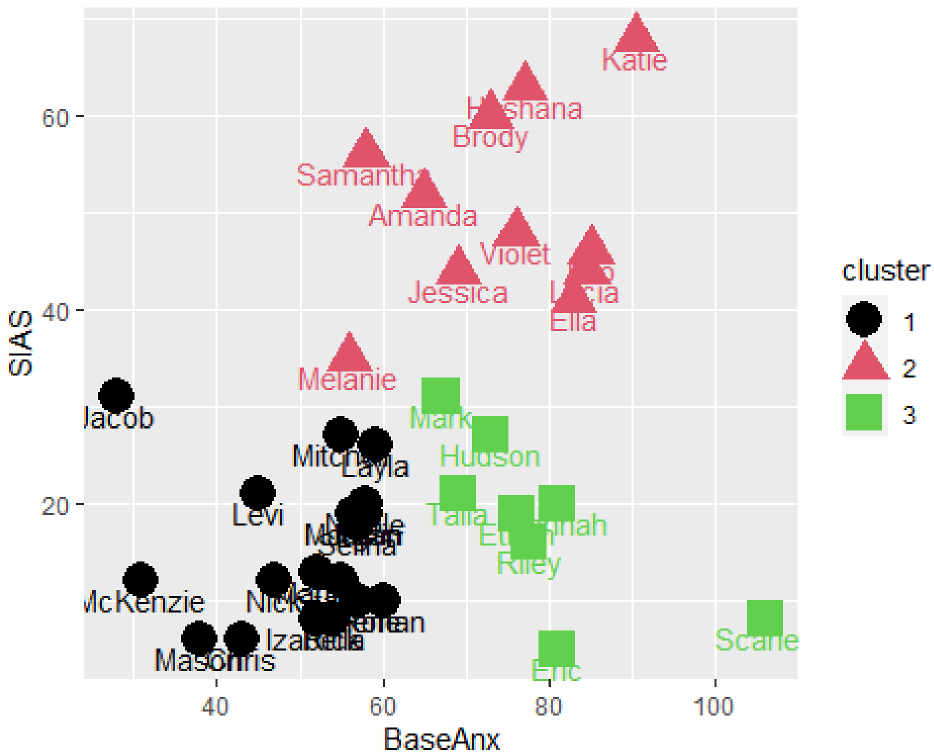
```
#getting number of clusters
fviz_nbclust(LBQData[,c(32,35:36)], kmeans, method = "wss")
```




```
#3 is the optimal number of clusters
#kmeans with 3 clusters
```

```r
groupkmeans = kmeans(LBQData[,c(32,35:36)], centers = 3, iter.max = 30
, nstart = 25)
names(groupkmeans)

## [1] "cluster"      "centers"      "totss"        "withinss"     "to
t.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"

head(groupkmeans)

## $cluster
##  [1] 2 2 1 1 2 1 2 1 3 1 2 2 3 3 2 3 1 3 1 1 1 1 1 2 1 1 3 3 2 2 1
1 1 2 1 1 1 3
##
## $centers
##    BaseAnx     SIAS       SPS
## 1 50.65789 15.63158  7.631579
## 2 74.27273 50.63636 41.000000
## 3 78.81250 18.37500 19.750000
##
## $totss
## [1] 32990.87
##
## $withinss
## [1] 3360.868 4368.227 2039.344
##
## $tot.withinss
## [1] 9768.439
##
## $betweenss
## [1] 23222.43

summary(groupkmeans)

##              Length Class  Mode
## cluster      38     -none- numeric
## centers       9     -none- numeric
## totss         1     -none- numeric
## withinss      3     -none- numeric
## tot.withinss  1     -none- numeric
## betweenss     1     -none- numeric
## size          3     -none- numeric
## iter          1     -none- numeric
## ifault        1     -none- numeric

#plotting the participants into three clusters
LBQData = LBQData %>% mutate(cluster = as.factor(groupkmeans$cluster))
```

```
LBQData$Name = as.factor(LBQData$Name)
ggplot(LBQData, aes(x = BaseAnx, y = SIAS, shape = cluster, color = cl
uster, label = paste (Name))) + geom_point(size =6) + scale_color_manu
al(values = 1:39)+ geom_text(aes(x = BaseAnx, y = SIAS, label = paste(
Name), vjust = 1.25))
```




```
#Research Question 1: How does age, gender, time abroad, onset age of
French, prior anxiety diagnoses, and immerse tendencies impact FLAQ, S
IAS, and SPS?
#Descriptive statistics for FLAQ
mean(LBQData$BaseAnx)

## [1] 63.42105

min(LBQData$BaseAnx)

## [1] 28

max(LBQData$BaseAnx)

## [1] 106

sd(LBQData$BaseAnx)

## [1] 16.63053
```

```
#Descriptive statistics for SIAS
LBQData$SIAS = as.numeric(LBQData$SIAS)
mean(LBQData$SIAS)

## [1] 26.34211

min(LBQData$SIAS)

## [1] 5

max(LBQData$SIAS)

## [1] 68

sd(LBQData$SIAS)

## [1] 17.79352

#Descriptive statistics for SPS
mean(LBQData$SPS)

## [1] 19.84211

min(LBQData$SPS)

## [1] 0

max(LBQData$SPS)

## [1] 66

sd(LBQData$SPS)

## [1] 17.27602

#-------------------------------------------------------------
#Does gender have an impact on baseline FLAQ, SIAS, or SPS?

GenderFLAQ = lm(BaseAnx~Gender, data = LBQData)
summary(GenderFLAQ)

##
## Call:
## lm(formula = BaseAnx ~ Gender, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -36.075 -10.075  -2.468  13.639  38.925
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)   67.075      3.665  18.303   <2e-16 ***
## GenderMale    -7.714      5.325  -1.449    0.156
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.39 on 36 degrees of freedom
## Multiple R-squared:  0.05509,    Adjusted R-squared:  0.02884
## F-statistic: 2.099 on 1 and 36 DF,  p-value: 0.1561

#not significantly, but males on average 8.154 points lower on anxiety

#What about on SIAS?
GenderSIAS = lm(SIAS~Gender, data = LBQData)
summary(GenderSIAS)

##
## Call:
## lm(formula = SIAS ~ Gender, data = LBQData)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -20.90 -13.35  -4.50  10.95  39.50
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   28.900      3.986   7.251 1.54e-08 ***
## GenderMale    -5.400      5.791  -0.932    0.357
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17.82 on 36 degrees of freedom
## Multiple R-squared:  0.02358,    Adjusted R-squared:  -0.003541
## F-statistic: 0.8695 on 1 and 36 DF,  p-value: 0.3573

#not significantly, but males have on average 5.742 points lower (p =
.315) -- same as what you found for preliminary exam.

#What about on SPS?
GenderSPS = lm(SPS~Gender, data = LBQData)
summary(GenderSPS)

##
## Call:
## lm(formula = SPS ~ Gender, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -22.200 -10.889  -4.044   7.050  40.800
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   25.200      3.695   6.820 5.67e-08 ***
## GenderMale   -11.311      5.369  -2.107   0.0422 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.53 on 36 degrees of freedom
## Multiple R-squared:  0.1098, Adjusted R-squared:  0.08503
## F-statistic: 4.438 on 1 and 36 DF,  p-value: 0.04217
```

```
females = LBQData %>% filter(Gender == "Female")
males = LBQData %>% filter(Gender == "Male")
mean(females$SPS)
```

```
## [1] 25.2
```

```
sd(females$SPS)
```

```
## [1] 17.86676
```

```
mean(males$SPS)
```

```
## [1] 13.88889
```

```
sd(males$SPS)
```

```
## [1] 14.88343
```

```
#Yes, males have on average 11.568 points lower (p = .033), aligned wi
th preliminary study results.

#Gender makes a difference, female students are more anxious both in t
erms of FLA and social anxiety.

#-----------------------------------------------------------------
#Does french onset have an impact on baseline FLA?
LBQData$OnsetFrench = as.numeric(LBQData$OnsetFrench)
OnsetFLAQ = lm(BaseAnx~OnsetFrench, data = LBQData)
summary(OnsetFLAQ)
```

```
##
## Call:
## lm(formula = BaseAnx ~ OnsetFrench, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -39.568  -8.720  -3.581  12.503  34.203
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  46.2565     8.2111   5.633 2.58e-06 ***
## OnsetFrench   1.2770     0.5918   2.158   0.0381 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.12 on 34 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.1205, Adjusted R-squared:  0.09459
## F-statistic: 4.656 on 1 and 34 DF,  p-value: 0.03809

#yes the earlier they studied French, the less anxious they were

#Does prior immersion experience impact baseline FLA
ImmersionFLAQ = lm(BaseAnx~SubstantialImmersion, data = LBQData)
summary(ImmersionFLAQ)

##
## Call:
## lm(formula = BaseAnx ~ SubstantialImmersion, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -37.389  -9.264  -2.591  10.611  40.611
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)               65.389      3.187  20.518   <2e-16 ***
## SubstantialImmersionYes   -6.798      5.923  -1.148    0.259
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.56 on 36 degrees of freedom
## Multiple R-squared:  0.0353, Adjusted R-squared:  0.008498
## F-statistic: 1.317 on 1 and 36 DF,  p-value: 0.2587

#not significantly but those who had substantial prior immersion exper
ience had on average FLA that was 5.483 points lower. (p = .515)

#------------------------------------------------------------------
#Do prior anxiety diagnoses impact FLA?
PriorDiagnosisFLAQ = lm(BaseAnx~AnxietyDiagnosis, data = LBQData)
summary(PriorDiagnosisFLAQ)
```

```
##
## Call:
## lm(formula = BaseAnx ~ AnxietyDiagnosis, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -31.192  -6.790  -1.192   9.808  33.417
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)            59.192      3.059   19.35   <2e-16 ***
## AnxietyDiagnosisYes    13.391      5.444    2.46   0.0188 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.6 on 36 degrees of freedom
## Multiple R-squared:  0.1439, Adjusted R-squared:  0.1201
## F-statistic:  6.05 on 1 and 36 DF,  p-value: 0.01884
```

```
yesdiagnosis = LBQData %>% filter(AnxietyDiagnosis == "Yes")
nodiagnosis = LBQData %>% filter(AnxietyDiagnosis == "No")
mean(yesdiagnosis$BaseAnx)
```

```
## [1] 72.58333
```

```
sd(yesdiagnosis$BaseAnx)
```

```
## [1] 17.63627
```

```
mean(nodiagnosis$BaseAnx)
```

```
## [1] 59.19231
```

```
sd(nodiagnosis$BaseAnx)
```

```
## [1] 14.61443
```

```
#yes, not surprising, those who had a prior official anxiety diagnosis
scored on average 15.64 points higher on FLAQ (p < .05)

#What about SIAS?
PriorDiagnosisSIAS = lm(SIAS~AnxietyDiagnosis, data = LBQData)
summary(PriorDiagnosisSIAS)
```

```
##
## Call:
## lm(formula = SIAS ~ AnxietyDiagnosis, data = LBQData)
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -28.750 -12.293  -3.423  11.207  37.077
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)            22.923      3.389   6.763 6.72e-08 ***
## AnxietyDiagnosisYes   10.827      6.031   1.795    0.081 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17.28 on 36 degrees of freedom
## Multiple R-squared:  0.08216,    Adjusted R-squared:  0.05666
## F-statistic: 3.222 on 1 and 36 DF,  p-value: 0.08103

#yes, but not significantly so, those who had a prior official anxiety diagnosis scored on average 11.05 points higher on SIAS (p = .07)

#What about SPS?
PriorDiagnosisSPS = lm(SPS~AnxietyDiagnosis, data = LBQData)
summary(PriorDiagnosisSPS)

##
## Call:
## lm(formula = SPS ~ AnxietyDiagnosis, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -28.750 -10.423  -2.423   7.995  32.250
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)            13.423      2.859   4.695  3.8e-05 ***
## AnxietyDiagnosisYes   20.327      5.088   3.995 0.000306 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.58 on 36 degrees of freedom
## Multiple R-squared:  0.3072, Adjusted R-squared:  0.288
## F-statistic: 15.96 on 1 and 36 DF,  p-value: 0.0003056

mean(yesdiagnosis$SPS)

## [1] 33.75

sd(yesdiagnosis$SPS)

## [1] 20.24004
```

```
mean(nodiagnosis$SPS)

## [1] 13.42308

sd(nodiagnosis$SPS)

## [1] 11.21489

#yes, those who had a prior official anxiety diagnosis scored on avera
ge 20.49 points higher on SPS (p < .001).

#-------------------------------------------------------------------
#Does knowledge of additional languages impact FLA?
AdditionalLanguagesFLAQ = lm(BaseAnx~Multilingual, data = LBQData)
summary(AdditionalLanguagesFLAQ)

##
## Call:
## lm(formula = BaseAnx ~ Multilingual, data = LBQData)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -31.696 -12.680  -1.696  12.945  46.304
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)       69.133      4.178  16.548   <2e-16 ***
## MultilingualYes   -9.438      5.370  -1.758   0.0873 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.18 on 36 degrees of freedom
## Multiple R-squared:  0.07902,    Adjusted R-squared:  0.05344
## F-statistic: 3.089 on 1 and 36 DF,  p-value: 0.08733

#-------------------------------------------------------------------
#Is there a correlation between FLAQ, SIAS, and SPS
#Looking at the correlation between SIAS and SPS
cor.test(LBQData$SIAS, LBQData$SPS,
                  method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  LBQData$SIAS and LBQData$SPS
## t = 8.0293, df = 36, p-value = 1.541e-09
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
```

```
##  0.6470743 0.8922467
## sample estimates:
##       cor
## 0.8010528

    #Pearson's product-moment correlation

#data:  LBQData$SIAS and LBQData$BaseAnx
#t = 2.6515, df = 37, p-value = 0.01173
#alternative hypothesis: true correlation is not equal to 0
#95 percent confidence interval:
 #0.09620609 0.63504507
#sample estimates:
 #     cor
#0.3995936


#Looking at the correlation between SIAS and BaselineAnx
#Pearson's product-moment correlation
cor.test(LBQData$SIAS, LBQData$BaseAnx,
                    method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  LBQData$SIAS and LBQData$BaseAnx
## t = 2.5693, df = 36, p-value = 0.01448
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.08461459 0.63359895
## sample estimates:
##       cor
## 0.3936498

#data:  LBQData$SIAS and LBQData$BaseAnx
#t = 2.6869, df = 38, p-value = 0.01064
#alternative hypothesis: true correlation is not equal to 0
#95 percent confidence interval:
 #0.1005801 0.6323687
#sample estimates:
 #     cor
#0.3995702

# significantly correlated

#Looking at the correlation between SPS and BaselineAnx
```

```
cor.test(LBQData$SPS, LBQData$BaseAnx,
                    method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  LBQData$SPS and LBQData$BaseAnx
## t = 4.0874, df = 36, p-value = 0.0002334
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.2967314 0.7480534
## sample estimates:
##       cor
## 0.5630078

#Pearson's product-moment correlation

#data:  LBQData$SPS and LBQData$BaseAnx
#t = 4.2005, df = 37, p-value = 0.0001609
#alternative hypothesis: true correlation is not equal to 0
#95 percent confidence interval:
 #0.3079214 0.7493929
#sample estimates:
 #     cor
#0.5682322

diss_data <- read_excel("dissertation_data.xlsx")
#RQ2a
#self-reported anxiety data
#Descriptive Stats for Self-reported anxiety scores
diss_data %>%
  group_by(Environment) %>%
  summarise(min = min(PostTask, na.rm = TRUE),
            max = max(PostTask, na.rm = TRUE),
            med = median(PostTask, na.rm = TRUE))

## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1            11    40  21
## 2 CR2            11    28  19
## 3 VR1            11    42  22
## 4 VR2            11    34  20
## 5 VR3            11    34  19
## 6 Z1             11    39  22
## 7 Z2             11    40  19
## 8 Z3             11    34  18.5
```

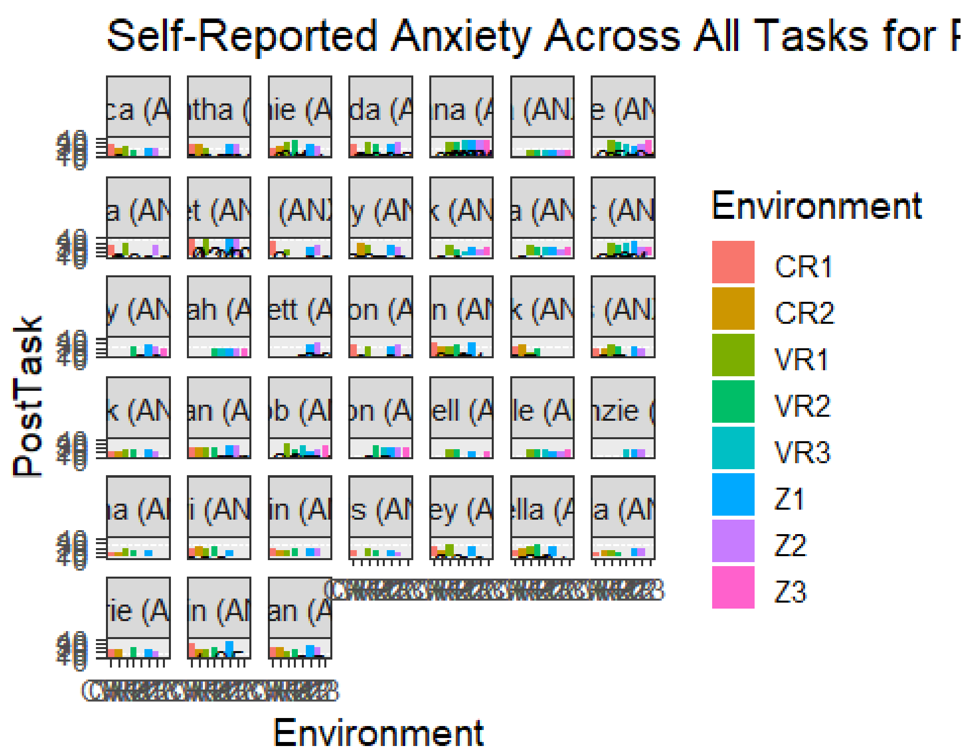
```
diss_data %>%
  group_by(Environment) %>%
  summarise(mean = mean(PostTask, na.rm = TRUE),
            sd = sd(PostTask, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 8 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1          21.7  7.91    25 1.58      18.5     25.0
## 2 CR2          19.1  5.10    25 1.02      16.9     21.2
## 3 VR1          22.4  7.13    38 1.16      20.0     24.7
## 4 VR2          20.5  5.81    38 0.943     18.6     22.4
## 5 VR3          20.8  7.10    13 1.97      16.5     25.1
## 6 Z1           21.9  6.89    38 1.12      19.7     24.2
## 7 Z2           20.8  6.98    38 1.13      18.5     23.1
## 8 Z3           20    7.50    13 2.08      15.5     24.5

#Looking at it by participant group
diss_data %>%
  group_by(AnxietyGroup) %>%
  summarise(min = min(PostTask, na.rm = TRUE),
            max = max(PostTask, na.rm = TRUE),
            med = median(PostTask, na.rm = TRUE))

## # A tibble: 3 x 4
##   AnxietyGroup   min   max   med
##   <chr>        <dbl> <dbl> <dbl>
## 1 ANX-            11    35  18
## 2 ANX+            11    42  26
## 3 ANX±            13    34  22.5

diss_data %>%
  group_by(AnxietyGroup) %>%
  summarise(mean = mean(PostTask, na.rm = TRUE),
            sd = sd(PostTask, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 3 x 7
##   AnxietyGroup  mean    sd     n    se lower.ci upper.ci
##   <chr>        <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
```

```
## 1 ANX-          18.2  4.97   114 0.466     17.3      19.1
## 2 ANX+          25.3  8.09    66 0.995     23.3      27.3
## 3 ANX±          22.7  4.95    48 0.715     21.3      24.1

#Looking only at high anx
high_anx = diss_data %>% filter(AnxietyGroup %in% c("ANX+"))
#descriptive data for high anxiety participants
high_anx %>%
  group_by(Environment) %>%
  summarise(min = min(PostTask, na.rm = TRUE),
            max = max(PostTask, na.rm = TRUE),
            med = median(PostTask, na.rm = TRUE))

## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1            17    40  28
## 2 CR2            19    28  24
## 3 VR1            13    42  28
## 4 VR2            11    34  27
## 5 VR3            11    34  25
## 6 Z1             11    39  24.5
## 7 Z2             11    40  24
## 8 Z3             11    34  33

high_anx %>%
  group_by(Environment) %>%
  summarise(mean = mean(PostTask, na.rm = TRUE),
            sd = sd(PostTask, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 8 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1          27.9  7.08     8  2.50     21.9      33.8
## 2 CR2          23.8  4.03     8  1.43     20.4      27.1
## 3 VR1          26.5  8.59    11  2.59     20.8      32.3
## 4 VR2          24    9.42    11  2.84     17.7      30.3
## 5 VR3          23.3 11.6      3  6.69     -5.46     52.1
## 6 Z1           24.5  8.14    11  2.45     19.0      30.0
## 7 Z2           24.7  8.31    11  2.50     19.1      30.3
## 8 Z3           26   13        3  7.51     -6.29     58.3
```

```
#Looking only at low anx
low_anx = diss_data %>% filter(AnxietyGroup %in% c("ANX-"))
#descriptive data for low anxiety participants
low_anx %>%
  group_by(Environment) %>%
  summarise(min = min(PostTask, na.rm = TRUE),
            max = max(PostTask, na.rm = TRUE),
            med = median(PostTask, na.rm = TRUE))

## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1            11    31  18
## 2 CR2            11    27  16
## 3 VR1            11    28  18
## 4 VR2            11    26  18
## 5 VR3            15    27  19
## 6 Z1             12    35  17.5
## 7 Z2             11    23  17
## 8 Z3             11    25  16.5

low_anx %>%
  group_by(Environment) %>%
  summarise(mean = mean(PostTask, na.rm = TRUE),
            sd = sd(PostTask, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 8 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1          17.6  5.72    14 1.53     14.3      20.9
## 2 CR2          17.3  4.57    14 1.22     14.7      19.9
## 3 VR1          18.9  5.18    19 1.19     16.4      21.4
## 4 VR2          18.7  4.16    19 0.955    16.7      20.7
## 5 VR3          20    5.60     5 2.50     13.0      27.0
## 6 Z1           19.1  5.77    19 1.32     16.3      21.9
## 7 Z2           16.6  4.03    19 0.925    14.6      18.5
## 8 Z3           17.2  6.13     5 2.74      9.64     24.9

#Looking only at med anx
med_anx = diss_data %>% filter(AnxietyGroup %in% c("ANX±"))
#descriptive data for high anxiety participants
med_anx %>%
  group_by(Environment) %>%
```

```
  summarise(min = min(PostTask, na.rm = TRUE),
            max = max(PostTask, na.rm = TRUE),
            med = median(PostTask, na.rm = TRUE))

## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1            26    33  29.5
## 2 CR2            23    23  23
## 3 VR1            22    29  24
## 4 VR2            16    27  22.5
## 5 VR3            13    28  19
## 6 Z1             18    34  24.5
## 7 Z2             17    29  21
## 8 Z3             16    22  18

med_anx %>%
  group_by(Environment) %>%
  summarise(mean = mean(PostTask, na.rm = TRUE),
            sd = sd(PostTask, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 8 x 7
##   Environment  mean    sd     n     se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int>  <dbl>    <dbl>    <dbl>
## 1 CR1          29.5  4.95     3  2.86      17.2     41.8
## 2 CR2          23   NA        3 NA         NA       NA
## 3 VR1          24.4  2.70     8  0.955     22.1     26.7
## 4 VR2          22.2  3.97     8  1.40      18.8     25.5
## 5 VR3          19.8  6.18     5  2.77      12.1     27.4
## 6 Z1           25.1  5.46     8  1.93      20.6     29.7
## 7 Z2           21.9  5.05     8  1.78      17.6     26.1
## 8 Z3           18.6  2.19     5  0.980     15.9     21.3

##Plotting
diss_data$Name = factor(diss_data$Name, levels =c("Jessica (ANX+)", "S
amantha (ANX+)", "Melanie (ANX+)", "Amanda (ANX+)", "Hashana (ANX+)",
"Ella (ANX+)", "Katie (ANX+)", "Lucia (ANX+)", "Violet (ANX+)", "Leo (
ANX+)", "Brody (ANX+)", "Mark (ANX±)", "Talia (ANX±)", "Eric (ANX±)",
"Riley (ANX±)", "Hannah (ANX±)", "Scarlett (ANX±)", "Hudson (ANX±)", "
Ethan (ANX±)", "Nick (ANX-)", "Iris (ANX-)", "Rick (ANX-)", "Rohan (AN
X-)", "Jacob (ANX-)", "Mason (ANX-)", "Mitchell (ANX-)", "Nicole (ANX-
)", "McKenzie (ANX-)", "Selina (ANX-)", "Levi (ANX-)", "Martin (ANX-)"
, "Chris (ANX-)", "Stacey (ANX-)", "Izabella (ANX-)", "Layla (ANX-)",
```

```
"Valerie (ANX-)", "Justin (ANX-)", "Morgan (ANX-)"))

ggplot(diss_data, aes(x = Environment, y = PostTask, fill = Environmen
t)) + geom_bar(stat = "identity") + facet_wrap(~Name) + ggtitle("Self-
Reported Anxiety Across All Tasks for Participants")+ geom_text(aes(x
= Environment, y = PostTask, label = paste(PostTask), vjust = 1.25)) +
theme_bw(14)

## Warning: Removed 37 rows containing missing values (position_stack)
.

## Warning: Removed 37 rows containing missing values (geom_text).
```




```
#Model for the impact of environment on anxiety
m_anx = lmerTest:: lmer(PostTask~Environment + AnxietyGroup + (1|Parti
cipant), data = diss_data)
summary(m_anx)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method
[
## lmerModLmerTest]
## Formula: PostTask ~ Environment + AnxietyGroup + (1 | Participant)
##    Data: diss_data
##
## REML criterion at convergence: 1120.2
##
```

```
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.23623 -0.54167 -0.06458  0.58266  2.84219
##
## Random effects:
##  Groups      Name        Variance Std.Dev.
##  Participant (Intercept) 20.86    4.567
##  Residual                16.38    4.047
## Number of obs: 191, groups:  Participant, 38
##
## Fixed effects:
##                  Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)       18.4978     1.3881  73.8572  13.326  < 2e-16 ***
## EnvironmentCR2    -1.4258     1.2967 148.1255  -1.100 0.273309
## EnvironmentVR1     0.4906     1.1297 148.4391   0.434 0.664686
## EnvironmentVR2    -0.1342     1.1770 150.7439  -0.114 0.909369
## EnvironmentVR3    -0.6300     1.6521 157.1501  -0.381 0.703487
## EnvironmentZ1      0.2814     1.1203 150.3439   0.251 0.801991
## EnvironmentZ2     -1.3796     1.1765 151.2126  -1.173 0.242798
## EnvironmentZ3     -1.4697     1.6060 156.4973  -0.915 0.361553
## AnxietyGroupANX+   7.5144     1.8683  35.1633   4.022 0.000291 ***
## AnxietyGroupANX±   5.0772     2.0971  36.2893   2.421 0.020601 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Warning in abbreviate(rn, minlength = 11): abbreviate used with non
-ASCII chars

##
## Correlation of Fixed Effects:

## Warning in abbreviate(rn, minlength = 6): abbreviate used with non-
ASCII chars

##              (Intr) EnvCR2 EnvVR1 EnvVR2 EnvVR3 EnvrZ1 EnvrZ2 EnvrZ3
AGANX+
## EnvrnmntCR2 -0.414
## EnvrnmntVR1 -0.474  0.491
## EnvrnmntVR2 -0.478  0.481  0.579
## EnvrnmntVR3 -0.366  0.336  0.455  0.469
## EnvirnmntZ1 -0.491  0.499  0.607  0.602  0.487
## EnvirnmntZ2 -0.460  0.465  0.582  0.575  0.480  0.612
## EnvirnmntZ3 -0.372  0.346  0.470  0.489  0.446  0.501  0.488
## AnxtyGrANX+ -0.490  0.024 -0.014  0.017 -0.006 -0.002 -0.027 -0.007
## AnxtyGrANX± -0.410  0.015 -0.026 -0.032 -0.060 -0.048 -0.059 -0.074
0.328
```

```r
anxiety.emm <- emmeans(m_anx, "Environment")
pairs(anxiety.emm)
```

```
##  contrast  estimate    SE  df t.ratio p.value
##  CR1 - CR2   1.4258 1.297 148   1.099  0.9561
##  CR1 - VR1  -0.4906 1.130 148  -0.434  0.9999
##  CR1 - VR2   0.1342 1.178 151   0.114  1.0000
##  CR1 - VR3   0.6300 1.656 157   0.380  0.9999
##  CR1 - Z1   -0.2814 1.121 150  -0.251  1.0000
##  CR1 - Z2    1.3796 1.178 151   1.171  0.9388
##  CR1 - Z3    1.4697 1.610 156   0.913  0.9845
##  CR2 - VR1  -1.9164 1.233 149  -1.554  0.7767
##  CR2 - VR2  -1.2916 1.266 150  -1.020  0.9707
##  CR2 - VR3  -0.7958 1.727 156  -0.461  0.9998
##  CR2 - Z1   -1.7072 1.221 150  -1.398  0.8567
##  CR2 - Z2   -0.0462 1.285 152  -0.036  1.0000
##  CR2 - Z3    0.0439 1.683 156   0.026  1.0000
##  VR1 - VR2   0.6249 1.059 148   0.590  0.9990
##  VR1 - VR3   1.1206 1.522 154   0.736  0.9957
##  VR1 - Z1    0.2092 0.998 148   0.210  1.0000
##  VR1 - Z2    1.8702 1.056 149   1.770  0.6410
##  VR1 - Z3    1.9603 1.469 153   1.335  0.8841
##  VR2 - VR3   0.4957 1.516 152   0.327  1.0000
##  VR2 - Z1   -0.4156 1.026 148  -0.405  0.9999
##  VR2 - Z2    1.2454 1.086 149   1.147  0.9451
##  VR2 - Z3    1.3355 1.456 150   0.917  0.9840
##  VR3 - Z1   -0.9114 1.479 152  -0.616  0.9986
##  VR3 - Z2    0.7496 1.501 152   0.499  0.9997
##  VR3 - Z3    0.8397 1.716 148   0.489  0.9997
##  Z1 - Z2     1.6610 1.014 147   1.639  0.7262
##  Z1 - Z3     1.7511 1.428 152   1.226  0.9229
##  Z2 - Z3     0.0901 1.458 152   0.062  1.0000
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 8 estima
tes
```

```r
anxietygroup.emm <- emmeans(m_anx, "AnxietyGroup")
pairs(anxietygroup.emm)
```

```
##  contrast        estimate   SE   df t.ratio p.value
##  (ANX-) - (ANX+)    -7.51 1.87 34.9  -4.022  0.0008
##  (ANX-) - ANX±      -5.08 2.10 36.0  -2.421  0.0527
##  (ANX+) - ANX±       2.44 2.31 35.7   1.056  0.5469
##
```

```
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 3 estima
tes
```

```
#Cohen's d calculated using Plonsky's calculator from workshop
confint(pairs(anxiety.emm))
```

```
##  contrast  estimate    SE  df lower.CL upper.CL
##  CR1 - CR2   1.4258 1.297 148    -2.56     5.41
##  CR1 - VR1  -0.4906 1.130 148    -3.97     2.98
##  CR1 - VR2   0.1342 1.178 151    -3.49     3.76
##  CR1 - VR3   0.6300 1.656 157    -4.46     5.72
##  CR1 - Z1   -0.2814 1.121 150    -3.73     3.17
##  CR1 - Z2    1.3796 1.178 151    -2.24     5.00
##  CR1 - Z3    1.4697 1.610 156    -3.48     6.42
##  CR2 - VR1  -1.9164 1.233 149    -5.71     1.88
##  CR2 - VR2  -1.2916 1.266 150    -5.18     2.60
##  CR2 - VR3  -0.7958 1.727 156    -6.10     4.51
##  CR2 - Z1   -1.7072 1.221 150    -5.46     2.05
##  CR2 - Z2   -0.0462 1.285 152    -4.00     3.90
##  CR2 - Z3    0.0439 1.683 156    -5.13     5.21
##  VR1 - VR2   0.6249 1.059 148    -2.63     3.88
##  VR1 - VR3   1.1206 1.522 154    -3.56     5.80
##  VR1 - Z1    0.2092 0.998 148    -2.86     3.28
##  VR1 - Z2    1.8702 1.056 149    -1.38     5.12
##  VR1 - Z3    1.9603 1.469 153    -2.55     6.47
##  VR2 - VR3   0.4957 1.516 152    -4.16     5.16
##  VR2 - Z1   -0.4156 1.026 148    -3.57     2.74
##  VR2 - Z2    1.2454 1.086 149    -2.09     4.58
##  VR2 - Z3    1.3355 1.456 150    -3.14     5.81
##  VR3 - Z1   -0.9114 1.479 152    -5.46     3.63
##  VR3 - Z2    0.7496 1.501 152    -3.86     5.36
##  VR3 - Z3    0.8397 1.716 148    -4.44     6.12
##  Z1 - Z2     1.6610 1.014 147    -1.46     4.78
##  Z1 - Z3     1.7511 1.428 152    -2.64     6.14
##  Z2 - Z3     0.0901 1.458 152    -4.39     4.57
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 8 est
imates
```

```
confint(pairs(anxietygroup.emm))
```

```
##  contrast        estimate   SE   df lower.CL upper.CL
##  (ANX-) - (ANX+)    -7.51 1.87 34.9    -12.1  -2.9411
##  (ANX-) - ANX±      -5.08 2.10 36.0    -10.2   0.0497
##  (ANX+) - ANX±       2.44 2.31 35.7     -3.2   8.0785
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 3 est
imates
```

```
#RQ2b
#Heart rate descriptive data as a whole
hr_data <- read_excel("dissertation_data.xlsx",
    sheet = "HRData")
hr_data %>%
  group_by(Session) %>%
  summarise(min = min(Mean, na.rm = TRUE),
            max = max(Mean, na.rm = TRUE),
            med = median(Mean, na.rm = TRUE))
```

```
## # A tibble: 8 x 4
##   Session   min   max   med
##   <chr>   <dbl> <dbl> <dbl>
## 1 CR1      64.2 107.   83.9
## 2 CR2      65.8 116.   86.4
## 3 VR1      62.9  84.7  68.6
## 4 VR2      66.7 102.   81.2
## 5 VR3      78.9  78.9  78.9
## 6 Z1       59.7 103.   75.1
## 7 Z2       57.6 102.   76.1
## 8 Z3       69.8  78.6  74.2
```

```
hr_data %>%
  group_by(Session) %>%
  summarise(mean = mean(Mean, na.rm = TRUE),
            sd = sd(Mean, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)
```

```
## Warning in qt(1 - (0.05/2), n - 1): NaNs produced

## Warning in qt(1 - (0.05/2), n - 1): NaNs produced
```

```
## # A tibble: 8 x 7
##   Session  mean    sd     n    se lower.ci upper.ci
##   <chr>   <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1      82.6 10.3     19  2.37     77.6     87.6
## 2 CR2      86.7 14.3     10  4.53     76.4     96.9
## 3 VR1      72.1  7.68    12  2.22     67.2     76.9
## 4 VR2      82.3  8.68    12  2.50     76.8     87.8
## 5 VR3      78.9 NA        1 NA        NA       NA
## 6 Z1       79.2 11.6     19  2.67     73.6     84.8
## 7 Z2       78.0 13.3     10  4.20     68.5     87.5
## 8 Z3       74.2  6.26     2  4.42     18.0    130.

#HR across all three environments globally
hr_data %>%
  group_by(Environment) %>%
  summarise(min = min(Mean, na.rm = TRUE),
            max = max(Mean, na.rm = TRUE),
            med = median(Mean, na.rm = TRUE))

## # A tibble: 3 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR           64.2  116.  84.6
## 2 VR           62.9  102.  78.4
## 3 Z            57.6  103.  75.4

hr_data %>%
  group_by(Environment) %>%
  summarise(mean = mean(Mean, na.rm = TRUE),
            sd = sd(Mean, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 3 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR           84.0 11.8     29  2.18     79.5     88.5
## 2 VR           77.3  9.38    25  1.88     73.4     81.1
## 3 Z            78.5 11.7     31  2.10     74.2     82.8

#Back to looking at each individual session
hr_data %>%
  group_by(Session) %>%
  summarise(mean = mean(Baseline, na.rm = TRUE))
```

```
## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      81.2
## 2 CR2      83.9
## 3 VR1      78.5
## 4 VR2      83.7
## 5 VR3      81.6
## 6 Z1       79.7
## 7 Z2       79.5
## 8 Z3       77.0
```

```
hr_data %>%
  group_by(AnxietyGroup) %>%
  summarise(min = min(Mean, na.rm = TRUE),
            max = max(Mean, na.rm = TRUE),
            med = median(Mean, na.rm = TRUE))
```

```
## # A tibble: 3 x 4
##   AnxietyGroup   min   max   med
##   <chr>        <dbl> <dbl> <dbl>
## 1 ANX-          57.6  97.5  76.6
## 2 ANX+          64.3 103.   79.4
## 3 ANX±          78.2 116.   86.9
```

```
hr_data %>%
  group_by(AnxietyGroup) %>%
  summarise(mean = mean(Mean, na.rm = TRUE),
            sd = sd(Mean, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)
```

```
## # A tibble: 3 x 7
##   AnxietyGroup  mean    sd     n    se lower.ci upper.ci
##   <chr>        <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 ANX-          77.3 10.4     51  1.46     74.4     80.3
## 2 ANX+          80.0  9.52    20  2.13     75.6     84.5
## 3 ANX±          89.8 12.2     14  3.26     82.8     96.8
```

```
hr_data %>%
  group_by(AnxietyGroup) %>%
  summarise(mean = mean(Baseline, na.rm = TRUE))
```

```
## # A tibble: 3 x 2
##   AnxietyGroup  mean
```

```
##   <chr>        <dbl>
## 1 ANX-          79.6
## 2 ANX+          83.2
## 3 ANX±          82.2
```

```
#HR data by group
high_anx_hr = hr_data %>% filter(AnxietyGroup %in% c("ANX+"))
low_anx_hr = hr_data %>% filter(AnxietyGroup %in% c("ANX-"))
med_anx_hr = hr_data %>% filter(AnxietyGroup %in% c("ANX±"))

#highanx
high_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Baseline, na.rm = TRUE))
```

```
## # A tibble: 6 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      81.3
## 2 CR2      99.1
## 3 VR1      78.5
## 4 VR2      86.8
## 5 Z1       83.7
## 6 Z2       83.0
```

```
high_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(MinHR, na.rm = TRUE))
```

```
## # A tibble: 6 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      64.8
## 2 CR2      78
## 3 VR1      52
## 4 VR2      70
## 5 Z1       70.8
## 6 Z2       66
```

```
high_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(MaxHR, na.rm = TRUE))
```

```
## # A tibble: 6 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1     100.
```

```
## 2 CR2      108
## 3 VR1       85
## 4 VR2       93.5
## 5 Z1        96.8
## 6 Z2        96.7

high_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Mean, na.rm = TRUE))

## # A tibble: 6 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      83.5
## 2 CR2      88.2
## 3 VR1      67.2
## 4 VR2      82.0
## 5 Z1       82.4
## 6 Z2       77.7

high_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Median, na.rm = TRUE))

## # A tibble: 6 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      83.3
## 2 CR2      88
## 3 VR1      67.7
## 4 VR2      82
## 5 Z1       81.8
## 6 Z2       77

high_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(SD, na.rm = TRUE))

## # A tibble: 6 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      5.35
## 2 CR2      4.75
## 3 VR1      6.70
## 4 VR2      3.93
## 5 Z1       4.89
## 6 Z2       5.05
```

```
#medanx
med_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Baseline, na.rm = TRUE))

## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      76.5
## 2 CR2      72.8
## 3 VR1      84.5
## 4 VR2      91.2
## 5 VR3      81.6
## 6 Z1       80.5
## 7 Z2       83.7
## 8 Z3       78.9

med_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(MinHR, na.rm = TRUE))

## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      69
## 2 CR2      63
## 3 VR1      64.5
## 4 VR2      72
## 5 VR3      67
## 6 Z1       69.5
## 7 Z2       79.5
## 8 Z3       66

med_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(MaxHR, na.rm = TRUE))

## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      127
## 2 CR2      133
## 3 VR1      104
## 4 VR2      108.
## 5 VR3      100
## 6 Z1       107.
```

```
## 7 Z2        112.
## 8 Z3         95
```

```
med_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Mean, na.rm = TRUE))
```

```
## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1     107.
## 2 CR2     116.
## 3 VR1      82.4
## 4 VR2      90.3
## 5 VR3      78.9
## 6 Z1       84.9
## 7 Z2       95.6
## 8 Z3       78.6
```

```
med_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Median, na.rm = TRUE))
```

```
## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1     110
## 2 CR2     117
## 3 VR1      82.5
## 4 VR2      89.5
## 5 VR3      78
## 6 Z1       84.8
## 7 Z2       96
## 8 Z3       79
```

```
med_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(SD, na.rm = TRUE))
```

```
## # A tibble: 8 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1       9.61
## 2 CR2      10.0
## 3 VR1       6.90
## 4 VR2       6.57
## 5 VR3       5.26
```

```
## 6 Z1        6.60
## 7 Z2        7.10
## 8 Z3        5.32

#lowanx
low_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Baseline, na.rm = TRUE))

## # A tibble: 7 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      81.5
## 2 CR2      83.4
## 3 VR1      76.8
## 4 VR2      81.1
## 5 Z1       77.4
## 6 Z2       75.8
## 7 Z3       75.1

low_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(MinHR, na.rm = TRUE))

## # A tibble: 7 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      66
## 2 CR2      70.6
## 3 VR1      59.3
## 4 VR2      66.8
## 5 Z1       59.8
## 6 Z2       59
## 7 Z3       60

low_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(MaxHR, na.rm = TRUE))

## # A tibble: 7 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      97
## 2 CR2      95.6
## 3 VR1      90.1
## 4 VR2      98.4
## 5 Z1       94.9
```

```
## 6 Z2        89.6
## 7 Z3        86
```

```
low_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Mean, na.rm = TRUE))
```

```
## # A tibble: 7 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      80.0
## 2 CR2      82.8
## 3 VR1      71.2
## 4 VR2      80.4
## 5 Z1       75.3
## 6 Z2       71.2
## 7 Z3       69.8
```

```
low_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(Median, na.rm = TRUE))
```

```
## # A tibble: 7 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      79.8
## 2 CR2      82.6
## 3 VR1      70.9
## 4 VR2      80
## 5 Z1       75.4
## 6 Z2       70.6
## 7 Z3       69
```

```
low_anx_hr %>%
  group_by(Session) %>%
  summarise(mean = mean(SD, na.rm = TRUE))
```

```
## # A tibble: 7 x 2
##   Session  mean
##   <chr>   <dbl>
## 1 CR1      5.26
## 2 CR2      4.26
## 3 VR1      5.75
## 4 VR2      5.40
## 5 Z1       6.93
## 6 Z2       5.58
## 7 Z3       5.12
```

```r
#Model for the impact of environment on heart rate
m_hr <- lmerTest:: lmer(Mean~Session + AnxietyGroup + (1|Participant),
data = hr_data)
hr.emm <- emmeans(m_hr, "Session")
pairs(hr.emm)
```

```
##  contrast  estimate   SE   df t.ratio p.value
##  CR1 - CR2   -4.248 3.20 59.2  -1.328  0.8845
##  CR1 - VR1   10.550 3.03 60.5   3.483  0.0196
##  CR1 - VR2    1.790 3.04 60.4   0.589  0.9989
##  CR1 - VR3   13.378 8.86 60.9   1.511  0.7987
##  CR1 - Z1     5.771 2.64 58.6   2.183  0.3768
##  CR1 - Z2     4.964 3.25 61.7   1.525  0.7909
##  CR1 - Z3    12.990 6.50 65.0   1.999  0.4909
##  CR2 - VR1   14.799 3.57 61.6   4.140  0.0026
##  CR2 - VR2    6.039 3.47 58.6   1.740  0.6618
##  CR2 - VR3   17.626 9.04 61.2   1.950  0.5229
##  CR2 - Z1    10.020 3.25 61.1   3.081  0.0580
##  CR2 - Z2     9.212 3.73 61.0   2.471  0.2274
##  CR2 - Z3    17.238 6.75 65.2   2.555  0.1916
##  VR1 - VR2   -8.760 3.33 59.5  -2.630  0.1659
##  VR1 - VR3    2.828 8.84 60.1   0.320  1.0000
##  VR1 - Z1    -4.779 3.08 63.6  -1.551  0.7769
##  VR1 - Z2    -5.586 3.54 61.2  -1.579  0.7607
##  VR1 - Z3     2.439 6.48 62.6   0.377  0.9999
##  VR2 - VR3   11.588 8.83 60.0   1.312  0.8908
##  VR2 - Z1     3.981 3.04 61.3   1.310  0.8916
##  VR2 - Z2     3.174 3.51 60.1   0.903  0.9847
##  VR2 - Z3    11.199 6.47 62.5   1.732  0.6669
##  VR3 - Z1    -7.607 8.75 61.1  -0.870  0.9877
##  VR3 - Z2    -8.414 8.88 60.4  -0.948  0.9798
##  VR3 - Z3    -0.388 9.94 57.8  -0.039  1.0000
##  Z1 - Z2     -0.807 3.24 62.2  -0.249  1.0000
##  Z1 - Z3      7.219 6.37 64.3   1.134  0.9468
##  Z2 - Z3      8.026 6.64 64.0   1.209  0.9263
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 8 estima
tes
```

```r
hrgroup.emm <- emmeans(m_hr, "AnxietyGroup")
pairs(hrgroup.emm)
```

```
##  contrast        estimate   SE   df t.ratio p.value
##  (ANX-) - (ANX+)    -3.42 3.50 19.9  -0.978  0.5986
```

```
##  (ANX-) - ANX±     -14.54 4.20 20.5  -3.465  0.0064
##  (ANX+) - ANX±     -11.12 4.75 21.1  -2.340  0.0719
##
## Results are averaged over the levels of: Session
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 3 estima
tes
```

```
#Cohen's d calculated using Plonsky's calculator in Excel
confint(pairs(hr.emm))
```

```
##  contrast  estimate   SE   df lower.CL upper.CL
##  CR1 - CR2   -4.248 3.20 59.2  -14.301     5.80
##  CR1 - VR1   10.550 3.03 60.5    1.042    20.06
##  CR1 - VR2    1.790 3.04 60.4   -7.754    11.33
##  CR1 - VR3   13.378 8.86 60.9  -14.415    41.17
##  CR1 - Z1     5.771 2.64 58.6   -2.538    14.08
##  CR1 - Z2     4.964 3.25 61.7   -5.246    15.17
##  CR1 - Z3    12.990 6.50 65.0   -7.366    33.35
##  CR2 - VR1   14.799 3.57 61.6    3.584    26.01
##  CR2 - VR2    6.039 3.47 58.6   -4.871    16.95
##  CR2 - VR3   17.626 9.04 61.2  -10.734    45.99
##  CR2 - Z1    10.020 3.25 61.1   -0.187    20.23
##  CR2 - Z2     9.212 3.73 61.0   -2.487    20.91
##  CR2 - Z3    17.238 6.75 65.2   -3.888    38.36
##  VR1 - VR2   -8.760 3.33 59.5  -19.223     1.70
##  VR1 - VR3    2.828 8.84 60.1  -24.934    30.59
##  VR1 - Z1    -4.779 3.08 63.6  -14.438     4.88
##  VR1 - Z2    -5.586 3.54 61.2  -16.689     5.52
##  VR1 - Z3     2.439 6.48 62.6  -17.871    22.75
##  VR2 - VR3   11.588 8.83 60.0  -16.152    39.33
##  VR2 - Z1     3.981 3.04 61.3   -5.555    13.52
##  VR2 - Z2     3.174 3.51 60.1   -7.860    14.21
##  VR2 - Z3    11.199 6.47 62.5   -9.079    31.48
##  VR3 - Z1    -7.607 8.75 61.1  -35.062    19.85
##  VR3 - Z2    -8.414 8.88 60.4  -36.291    19.46
##  VR3 - Z3    -0.388 9.94 57.8  -31.641    30.86
##  Z1 - Z2     -0.807 3.24 62.2  -10.958     9.34
##  Z1 - Z3      7.219 6.37 64.3  -12.733    27.17
##  Z2 - Z3      8.026 6.64 64.0  -12.774    28.83
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 8 est
imates
```

```
confint(pairs(hrgroup.emm))

##  contrast        estimate   SE   df lower.CL upper.CL
##  (ANX-) - (ANX+)    -3.42 3.50 19.9    -12.3    5.434
##  (ANX-) - ANX±     -14.54 4.20 20.5    -25.1   -3.945
##  (ANX+) - ANX±     -11.12 4.75 21.1    -23.1    0.857
##
## Results are averaged over the levels of: Session
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 3 est
imates

#rq3
#starting with comprehensibility
#comp. interrater reliability
comp_rel <- read_excel("rq3_data.xlsx", sheet = "CompReliability_ACJ")
ICC(x=comp_rel, missing = TRUE, alpha = 0.05)

## Call: ICC(x = comp_rel, missing = TRUE, alpha = 0.05)
##
## Intraclass correlation coefficients
##                           type  ICC   F df1  df2        p lower boun
d
## Single_raters_absolute   ICC1 0.34 3.0 569 1710  1.1e-68        0.3
0
## Single_random_raters     ICC2 0.39 6.2 569 1707 3.4e-190        0.2
0
## Single_fixed_raters      ICC3 0.57 6.2 569 1707 3.4e-190        0.5
3
## Average_raters_absolute ICC1k 0.67 3.0 569 1710  1.1e-68        0.6
3
## Average_random_raters   ICC2k 0.72 6.2 569 1707 3.4e-190        0.5
0
## Average_fixed_raters    ICC3k 0.84 6.2 569 1707 3.4e-190        0.8
2
##                         upper bound
## Single_raters_absolute         0.38
## Single_random_raters           0.53
## Single_fixed_raters            0.60
## Average_raters_absolute        0.71
## Average_random_raters          0.82
## Average_fixed_raters           0.86
##
##  Number of subjects = 570     Number of Judges =  4
```

```
## See the help file for a discussion of the other 4 McGraw and Wong e
stimates,

#reliability = .84 #strong

#descriptive data
speechdata <- read_excel("dissertation_data.xlsx",
    sheet = "rq3")
min(speechdata$ComprehensibilityRaw)

## [1] 3.111111

max(speechdata$ComprehensibilityRaw)

## [1] 9

speechdata %>%
  group_by(Environment) %>%
  summarise(min = min(ComprehensibilityRaw, na.rm = TRUE),
            max = max(ComprehensibilityRaw, na.rm = TRUE),
            med = median(ComprehensibilityRaw, na.rm = TRUE))

## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1          3.67  8.5   6.17
## 2 CR2          4.33  8.22  6.67
## 3 VR1          4.11  8.89  7.67
## 4 VR2          4.83  8.67  7.58
## 5 VR3          6.33  8.67  8.06
## 6 Z1           3.11  8.78  7.61
## 7 Z2           3.83  9     8
## 8 Z3           6.78  8.78  8

speechdata %>%
  group_by(Environment) %>%
  summarise(mean = mean(ComprehensibilityRaw, na.rm = TRUE),
            sd = sd(ComprehensibilityRaw, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 8 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1          6.23 1.34     23 0.279     5.65     6.81
## 2 CR2          6.69 1.23     18 0.290     6.08     7.31
```

```
## 3 VR1          7.47 1.11     33 0.194     7.08     7.87
## 4 VR2          7.29 1.13     30 0.207     6.87     7.71
## 5 VR3          7.97 0.601    12 0.174     7.59     8.35
## 6 Z1           7.25 1.22     36 0.203     6.84     7.66
## 7 Z2           7.70 1.08     30 0.197     7.30     8.10
## 8 Z3           7.87 0.624    11 0.188     7.45     8.29

speechdata %>%
  group_by(AnxietyGroup) %>%
  summarise(min = min(ComprehensibilityRaw, na.rm = TRUE),
            max = max(ComprehensibilityRaw, na.rm = TRUE),
            med = median(ComprehensibilityRaw, na.rm = TRUE))

## # A tibble: 3 x 4
##   AnxietyGroup   min   max   med
##   <chr>        <dbl> <dbl> <dbl>
## 1 ANX-          3.83  9     7.5
## 2 ANX+          3.11  8.67  7.78
## 3 ANX±          4.83  8.67  7.83

speechdata %>%
  group_by(AnxietyGroup) %>%
  summarise(mean = mean(ComprehensibilityRaw, na.rm = TRUE),
            sd = sd(ComprehensibilityRaw, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 3 x 7
##   AnxietyGroup  mean    sd     n    se lower.ci upper.ci
##   <chr>        <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 ANX-          7.32  1.09    99 0.110     7.10     7.53
## 2 ANX+          7.18  1.43    56 0.191     6.79     7.56
## 3 ANX±          7.29  1.20    38 0.195     6.89     7.68

m_comp = lmerTest:: lmer(ComprehensibilityRaw~Environment + AnxietyGro
up + (1|Participant), data = speechdata)
summary(m_comp)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method
[
## lmerModLmerTest]
## Formula: ComprehensibilityRaw ~ Environment + AnxietyGroup + (1 | P
articipant)
##    Data: speechdata
##
```

```
## REML criterion at convergence: 473.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.14965 -0.46552  0.09814  0.59987  2.57053
##
## Random effects:
##  Groups      Name        Variance Std.Dev.
##  Participant (Intercept) 0.9419   0.9705
##  Residual                0.4040   0.6356
## Number of obs: 193, groups:  Participant, 38
##
## Fixed effects:
##                  Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)        6.6520     0.2648  56.6443  25.118  < 2e-16 ***
## EnvironmentCR2     0.4387     0.2038 148.5074   2.153 0.032944 *
## EnvironmentVR1     1.0035     0.1770 148.9645   5.668 7.24e-08 ***
## EnvironmentVR2     0.8288     0.1824 149.5916   4.545 1.13e-05 ***
## EnvironmentVR3     0.9112     0.2544 154.6364   3.581 0.000458 ***
## EnvironmentZ1      0.7002     0.1763 149.9043   3.972 0.000110 ***
## EnvironmentZ2      1.0976     0.1840 150.1540   5.964 1.69e-08 ***
## EnvironmentZ3      0.8478     0.2614 153.7087   3.243 0.001451 **
## AnxietyGroupANX+  -0.2617     0.3835  34.3226  -0.682 0.499553
## AnxietyGroupANX±  -0.3298     0.4293  35.1377  -0.768 0.447520
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Warning in abbreviate(rn, minlength = 11): abbreviate used with non
-ASCII chars

##
## Correlation of Fixed Effects:

## Warning in abbreviate(rn, minlength = 6): abbreviate used with non-
ASCII chars

##             (Intr) EnvCR2 EnvVR1 EnvVR2 EnvVR3 EnvrZ1 EnvrZ2 EnvrZ3
AGANX+
## EnvrnmntCR2 -0.340
## EnvrnmntVR1 -0.394  0.492
## EnvrnmntVR2 -0.394  0.484  0.585
## EnvrnmntVR3 -0.317  0.343  0.481  0.470
## EnvirnmntZ1 -0.407  0.497  0.614  0.603  0.503
## EnvirnmntZ2 -0.384  0.468  0.591  0.576  0.489  0.610
## EnvirnmntZ3 -0.297  0.334  0.467  0.463  0.454  0.489  0.475
## AnxtyGrANX+ -0.529  0.017 -0.010  0.008  0.001 -0.002 -0.017 -0.009
```

```
## AnxtyGrANX± -0.457  0.011 -0.024 -0.028 -0.039 -0.036 -0.032 -0.059
0.328
```

```
comp.emm <- emmeans(m_comp, "Environment")
pairs(comp.emm)
```

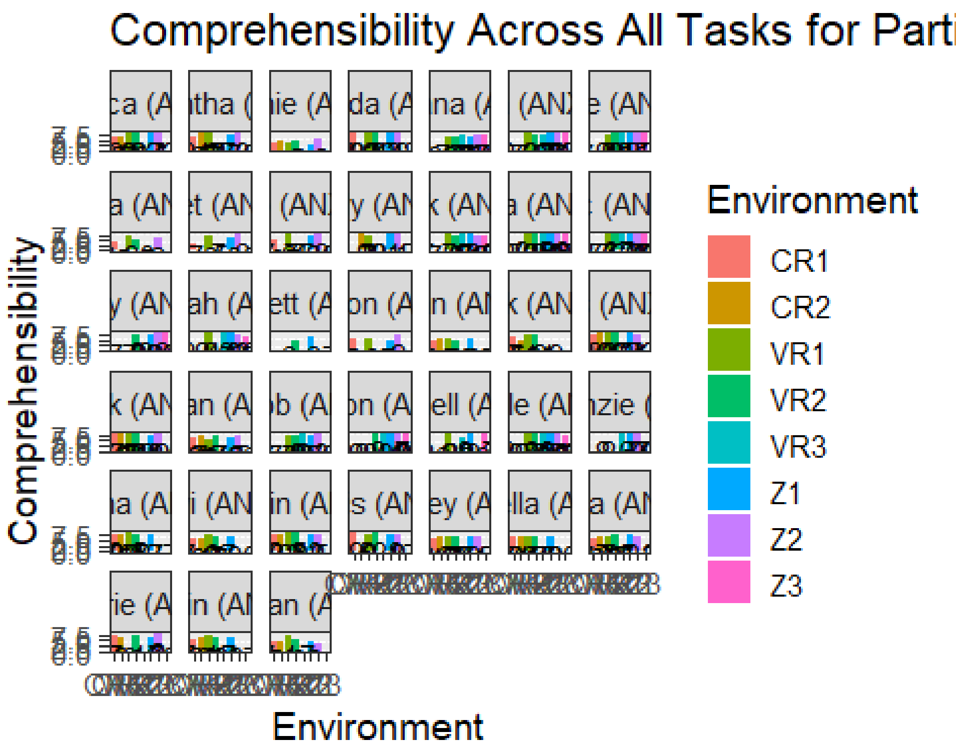
```
##  contrast  estimate    SE  df t.ratio p.value
##  CR1 - CR2   -0.4387 0.204 149  -2.152  0.3868
##  CR1 - VR1   -1.0035 0.177 149  -5.666  <.0001
##  CR1 - VR2   -0.8288 0.182 150  -4.542  0.0003
##  CR1 - VR3   -0.9112 0.255 155  -3.575  0.0108
##  CR1 - Z1    -0.7002 0.176 150  -3.970  0.0027
##  CR1 - Z2    -1.0976 0.184 151  -5.961  <.0001
##  CR1 - Z3    -0.8478 0.262 154  -3.238  0.0311
##  CR2 - VR1   -0.5649 0.193 150  -2.921  0.0756
##  CR2 - VR2   -0.3901 0.197 150  -1.980  0.4990
##  CR2 - VR3   -0.4725 0.266 155  -1.774  0.6385
##  CR2 - Z1    -0.2615 0.192 150  -1.361  0.8732
##  CR2 - Z2    -0.6589 0.201 151  -3.280  0.0275
##  CR2 - Z3    -0.4091 0.273 154  -1.499  0.8072
##  VR1 - VR2    0.1747 0.164 149   1.067  0.9626
##  VR1 - VR3    0.0924 0.230 153   0.402  0.9999
##  VR1 - Z1     0.3034 0.155 149   1.954  0.5165
##  VR1 - Z2    -0.0941 0.164 149  -0.575  0.9991
##  VR1 - Z3     0.1557 0.238 152   0.655  0.9980
##  VR2 - VR3   -0.0823 0.233 153  -0.353  1.0000
##  VR2 - Z1     0.1286 0.160 149   0.804  0.9927
##  VR2 - Z2    -0.2688 0.169 150  -1.592  0.7542
##  VR2 - Z3    -0.0190 0.240 152  -0.079  1.0000
##  VR3 - Z1     0.2110 0.225 152   0.936  0.9820
##  VR3 - Z2    -0.1865 0.230 152  -0.811  0.9923
##  VR3 - Z3     0.0633 0.270 149   0.235  1.0000
##  Z1 - Z2     -0.3975 0.159 149  -2.494  0.2061
##  Z1 - Z3     -0.1477 0.233 152  -0.633  0.9984
##  Z2 - Z3      0.2498 0.238 151   1.050  0.9658
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 8 estima
tes
```

```
groupcomp.emm <- emmeans(m_comp, "AnxietyGroup")
pairs(groupcomp.emm)
```

```
##  contrast        estimate    SE   df t.ratio p.value
##  (ANX-) - (ANX+)   0.2617 0.384 34.9   0.682  0.7752
##  (ANX-) - ANX±     0.3298 0.429 35.7   0.768  0.7247
```

```
##  (ANX+) - ANX±     0.0681 0.473 35.5   0.144  0.9886
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 3 estima
tes

#Cohen's d calculated using Plonsky's calculator from workshop
confint(pairs(comp.emm))

##  contrast  estimate    SE  df lower.CL upper.CL
##  CR1 - CR2  -0.4387 0.204 149   -1.065   0.1879
##  CR1 - VR1  -1.0035 0.177 149   -1.548  -0.4591
##  CR1 - VR2  -0.8288 0.182 150   -1.390  -0.2679
##  CR1 - VR3  -0.9112 0.255 155   -1.694  -0.1280
##  CR1 - Z1   -0.7002 0.176 150   -1.242  -0.1580
##  CR1 - Z2   -1.0976 0.184 151   -1.664  -0.5316
##  CR1 - Z3   -0.8478 0.262 154   -1.652  -0.0433
##  CR2 - VR1  -0.5649 0.193 150   -1.159   0.0296
##  CR2 - VR2  -0.3901 0.197 150   -0.996   0.2157
##  CR2 - VR3  -0.4725 0.266 155   -1.291   0.3459
##  CR2 - Z1   -0.2615 0.192 150   -0.852   0.3291
##  CR2 - Z2   -0.6589 0.201 151   -1.277  -0.0414
##  CR2 - Z3   -0.4091 0.273 154   -1.248   0.4299
##  VR1 - VR2   0.1747 0.164 149   -0.329   0.6782
##  VR1 - VR3   0.0924 0.230 153   -0.615   0.7993
##  VR1 - Z1    0.3034 0.155 149   -0.174   0.7807
##  VR1 - Z2   -0.0941 0.164 149   -0.597   0.4086
##  VR1 - Z3    0.1557 0.238 152   -0.575   0.8865
##  VR2 - VR3  -0.0823 0.233 153   -0.800   0.6350
##  VR2 - Z1    0.1286 0.160 149   -0.363   0.6203
##  VR2 - Z2   -0.2688 0.169 150   -0.788   0.2502
##  VR2 - Z3   -0.0190 0.240 152   -0.756   0.7184
##  VR3 - Z1    0.2110 0.225 152   -0.482   0.9035
##  VR3 - Z2   -0.1865 0.230 152   -0.893   0.5204
##  VR3 - Z3    0.0633 0.270 149   -0.765   0.8921
##  Z1 - Z2    -0.3975 0.159 149   -0.887   0.0925
##  Z1 - Z3    -0.1477 0.233 152   -0.865   0.5695
##  Z2 - Z3     0.2498 0.238 151   -0.482   0.9813
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 8 est
imates
```

```
confint(pairs(groupcomp.emm))

##  contrast        estimate    SE   df lower.CL upper.CL
##  (ANX-) - (ANX+)   0.2617 0.384 34.9   -0.677     1.20
##  (ANX-) - ANX±     0.3298 0.429 35.7   -0.720     1.38
##  (ANX+) - ANX±     0.0681 0.473 35.5   -1.088     1.22
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 3 est
imates

#plotting comprehensibility scores
require(ggplot2)
speechdata$Participant = factor(speechdata$Participant, levels =c("Jes
sica (ANX+)", "Samantha (ANX+)", "Melanie (ANX+)", "Amanda (ANX+)", "H
ashana (ANX+)", "Ella (ANX+)", "Katie (ANX+)", "Lucia (ANX+)", "Violet
(ANX+)", "Leo (ANX+)", "Brody (ANX+)", "Mark (ANX±)", "Talia (ANX±)",
"Eric (ANX±)", "Riley (ANX±)", "Hannah (ANX±)", "Scarlett (ANX±)", "Hu
dson (ANX±)", "Ethan (ANX±)", "Nick (ANX-)", "Iris (ANX-)", "Rick (ANX
-)", "Rohan (ANX-)", "Jacob (ANX-)", "Mason (ANX-)", "Mitchell (ANX-)"
, "Nicole (ANX-)", "McKenzie (ANX-)", "Selina (ANX-)", "Levi (ANX-)",
"Martin (ANX-)", "Chris (ANX-)", "Stacey (ANX-)", "Izabella (ANX-)", "
Layla (ANX-)", "Valerie (ANX-)", "Justin (ANX-)", "Morgan (ANX-)"))

ggplot(speechdata, aes(x = Environment, y = Comprehensibility, fill =
Environment)) + geom_bar(stat = "identity") + facet_wrap(~Participant)
+ ggtitle("Comprehensibility Across All Tasks for Participants")+ geom
_text(aes(x = Environment, y = Comprehensibility, label = paste(Compre
hensibility), vjust = 1.25)) + theme_bw(14)
```




```
#moving onto intelligibility
#intell. interrater reliability
intell_rel <- read_excel("rq3_data.xlsx", sheet = "intellrel")
ICC(x=intell_rel, missing = TRUE, alpha = 0.05)

## Call: ICC(x = intell_rel, missing = TRUE, alpha = 0.05)
##
## Intraclass correlation coefficients
##                          type  ICC   F df1  df2        p lower boun
d
## Single_raters_absolute   ICC1 0.38 3.5 569 1710  1.6e-87        0.3
5
## Single_random_raters     ICC2 0.42 5.4 569 1707 1.4e-159        0.2
9
## Single_fixed_raters      ICC3 0.52 5.4 569 1707 1.4e-159        0.4
9
## Average_raters_absolute ICC1k 0.71 3.5 569 1710  1.6e-87        0.6
8
## Average_random_raters   ICC2k 0.74 5.4 569 1707 1.4e-159        0.6
2
## Average_fixed_raters    ICC3k 0.81 5.4 569 1707 1.4e-159        0.7
9
##                         upper bound
## Single_raters_absolute         0.42
## Single_random_raters           0.52
```

```
## Single_fixed_raters          0.56
## Average_raters_absolute      0.74
## Average_random_raters        0.81
## Average_fixed_raters         0.83
##
##  Number of subjects = 570     Number of Judges =  4
## See the help file for a discussion of the other 4 McGraw and Wong e
stimates,
```

```
#reliability = .81

#descriptive data
min(speechdata$IntelligibilityRaw)
```

```
## [1] 59.33333
```

```
max(speechdata$IntelligibilityRaw)
```

```
## [1] 93
```

```
speechdata %>%
  group_by(Environment) %>%
  summarise(min = min(IntelligibilityRaw, na.rm = TRUE),
            max = max(IntelligibilityRaw, na.rm = TRUE),
            med = median(IntelligibilityRaw, na.rm = TRUE))
```

```
## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1          59.5  85.1  69.7
## 2 CR2          59.9  85.8  72
## 3 VR1          66.2  91.2  80.7
## 4 VR2          59.3  89.8  80.7
## 5 VR3          75.2  90.9  80.2
## 6 Z1           65.3  93    78.8
## 7 Z2           59.8  90.9  81.1
## 8 Z3           70.4  90.4  80
```

```
speechdata %>%
  group_by(Environment) %>%
  summarise(mean = mean(IntelligibilityRaw, na.rm = TRUE),
            sd = sd(IntelligibilityRaw, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)
```

```
## # A tibble: 8 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1          69.6  6.51    23 1.36      66.7     72.4
## 2 CR2          71.9  8.12    18 1.91      67.8     75.9
## 3 VR1          80.8  5.27    33 0.917     79.0     82.7
## 4 VR2          79.0  8.17    30 1.49      76.0     82.1
## 5 VR3          81.5  5.16    12 1.49      78.2     84.7
## 6 Z1           80.1  7.29    36 1.21      77.6     82.5
## 7 Z2           80.7  6.10    30 1.11      78.5     83.0
## 8 Z3           80.7  7.85    11 2.37      75.4     85.9

speechdata %>%
  group_by(AnxietyGroup) %>%
  summarise(min = min(IntelligibilityRaw, na.rm = TRUE),
            max = max(IntelligibilityRaw, na.rm = TRUE),
            med = median(IntelligibilityRaw, na.rm = TRUE))

## # A tibble: 3 x 4
##   AnxietyGroup   min   max   med
##   <chr>        <dbl> <dbl> <dbl>
## 1 ANX-          59.3  93    77.5
## 2 ANX+          59.5  91.6  80.3
## 3 ANX±          62.2  90.2  79.4

speechdata %>%
  group_by(AnxietyGroup) %>%
  summarise(mean = mean(IntelligibilityRaw, na.rm = TRUE),
            sd = sd(IntelligibilityRaw, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 3 x 7
##   AnxietyGroup  mean    sd     n    se lower.ci upper.ci
##   <chr>        <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 ANX-          77.3  8.04    99 0.808     75.6     78.9
## 2 ANX+          80.0  7.79    56 1.04      77.9     82.1
## 3 ANX±          78.3  7.35    38 1.19      75.9     80.7

m_intell = lmerTest:: lmer(IntelligibilityRaw~Environment + AnxietyGro
up + (1|Participant), data = speechdata)
summary(m_intell)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method
[
```

```
## lmerModLmerTest]
## Formula: IntelligibilityRaw ~ Environment + AnxietyGroup + (1 | Par
ticipant)
##    Data: speechdata
##
## REML criterion at convergence: 1222.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.59651 -0.56851 -0.03122  0.67316  2.43452
##
## Random effects:
##  Groups      Name        Variance Std.Dev.
##  Participant (Intercept) 16.53    4.066
##  Residual                30.54    5.526
## Number of obs: 193, groups:  Participant, 38
##
## Fixed effects:
##                   Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)        70.0150     1.5466 107.4938  45.271  < 2e-16 ***
## EnvironmentCR2      2.3838     1.7646 151.2412   1.351    0.179
## EnvironmentVR1     10.4557     1.5307 152.3997   6.831 1.89e-10 ***
## EnvironmentVR2      8.9746     1.5730 154.2160   5.705 5.77e-08 ***
## EnvironmentVR3      9.5480     2.1524 167.9097   4.436 1.65e-05 ***
## EnvironmentZ1       9.5351     1.5189 154.8734   6.278 3.30e-09 ***
## EnvironmentZ2       9.8529     1.5841 155.7125   6.220 4.39e-09 ***
## EnvironmentZ3       9.0488     2.2193 165.8028   4.077 7.06e-05 ***
## AnxietyGroupANX+    1.8106     1.8067  34.4534   1.002    0.323
## AnxietyGroupANX±   -0.5445     2.0470  36.5799  -0.266    0.792
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Warning in abbreviate(rn, minlength = 11): abbreviate used with non
-ASCII chars

##
## Correlation of Fixed Effects:

## Warning in abbreviate(rn, minlength = 6): abbreviate used with non-
ASCII chars

##             (Intr) EnvCR2 EnvVR1 EnvVR2 EnvVR3 EnvrZ1 EnvrZ2 EnvrZ3
AGANX+
## EnvrnmntCR2 -0.506
## EnvrnmntVR1 -0.579  0.495
## EnvrnmntVR2 -0.579  0.487  0.584
## EnvrnmntVR3 -0.459  0.352  0.474  0.465
```

```
## EnvirnmntZ1 -0.596  0.501  0.611  0.600  0.493
## EnvirnmntZ2 -0.563  0.473  0.588  0.573  0.478  0.605
## EnvirnmntZ3 -0.430  0.341  0.461  0.456  0.430  0.480  0.464
## AnxtyGrANX+ -0.422  0.030 -0.020  0.013 -0.002 -0.005 -0.033 -0.019
## AnxtyGrANX± -0.334  0.020 -0.043 -0.046 -0.071 -0.061 -0.056 -0.107
0.326
```

```
intell.emm <- emmeans(m_intell, "Environment")
pairs(intell.emm)
```

```
##  contrast  estimate   SE  df t.ratio p.value
##  CR1 - CR2  -2.3838 1.77 151  -1.350  0.8779
##  CR1 - VR1 -10.4557 1.53 153  -6.824  <.0001
##  CR1 - VR2  -8.9746 1.58 154  -5.698  <.0001
##  CR1 - VR3  -9.5480 2.16 168  -4.416  0.0005
##  CR1 - Z1   -9.5351 1.52 155  -6.269  <.0001
##  CR1 - Z2   -9.8529 1.59 156  -6.209  <.0001
##  CR1 - Z3   -9.0488 2.23 166  -4.061  0.0019
##  CR2 - VR1  -8.0718 1.67 154  -4.831  0.0001
##  CR2 - VR2  -6.5908 1.70 155  -3.875  0.0038
##  CR2 - VR3  -7.1642 2.26 167  -3.167  0.0378
##  CR2 - Z1   -7.1513 1.66 155  -4.318  0.0007
##  CR2 - Z2   -7.4690 1.73 157  -4.321  0.0007
##  CR2 - Z3   -6.6650 2.33 165  -2.865  0.0867
##  VR1 - VR2   1.4810 1.42 152   1.045  0.9667
##  VR1 - VR3   0.9076 1.97 161   0.461  0.9998
##  VR1 - Z1    0.9206 1.35 151   0.684  0.9973
##  VR1 - Z2    0.6028 1.42 152   0.426  0.9999
##  VR1 - Z3    1.4069 2.04 160   0.690  0.9972
##  VR2 - VR3  -0.5734 2.00 162  -0.287  1.0000
##  VR2 - Z1   -0.5604 1.39 151  -0.405  0.9999
##  VR2 - Z2   -0.8782 1.46 153  -0.602  0.9988
##  VR2 - Z3   -0.0742 2.06 159  -0.036  1.0000
##  VR3 - Z1    0.0130 1.93 160   0.007  1.0000
##  VR3 - Z2   -0.3048 1.98 159  -0.154  1.0000
##  VR3 - Z3    0.4992 2.34 151   0.214  1.0000
##  Z1 - Z2    -0.3178 1.38 151  -0.230  1.0000
##  Z1 - Z3     0.4863 2.00 159   0.243  1.0000
##  Z2 - Z3     0.8040 2.05 158   0.393  0.9999
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 8 estima
tes
```

```
groupintell.emm <- emmeans(m_intell, "AnxietyGroup")
pairs(groupintell.emm)
```

```
##  contrast        estimate   SE   df t.ratio p.value
##  (ANX-) - (ANX+)   -1.811 1.81 34.6  -1.002  0.5806
##  (ANX-) - ANX±      0.545 2.05 36.7   0.266  0.9618
##  (ANX+) - ANX±      2.355 2.25 36.1   1.048  0.5520
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 3 estima
tes
```

```
#Cohen's d calculated using Plonsky's calculator from workshop
confint(pairs(intell.emm))
```

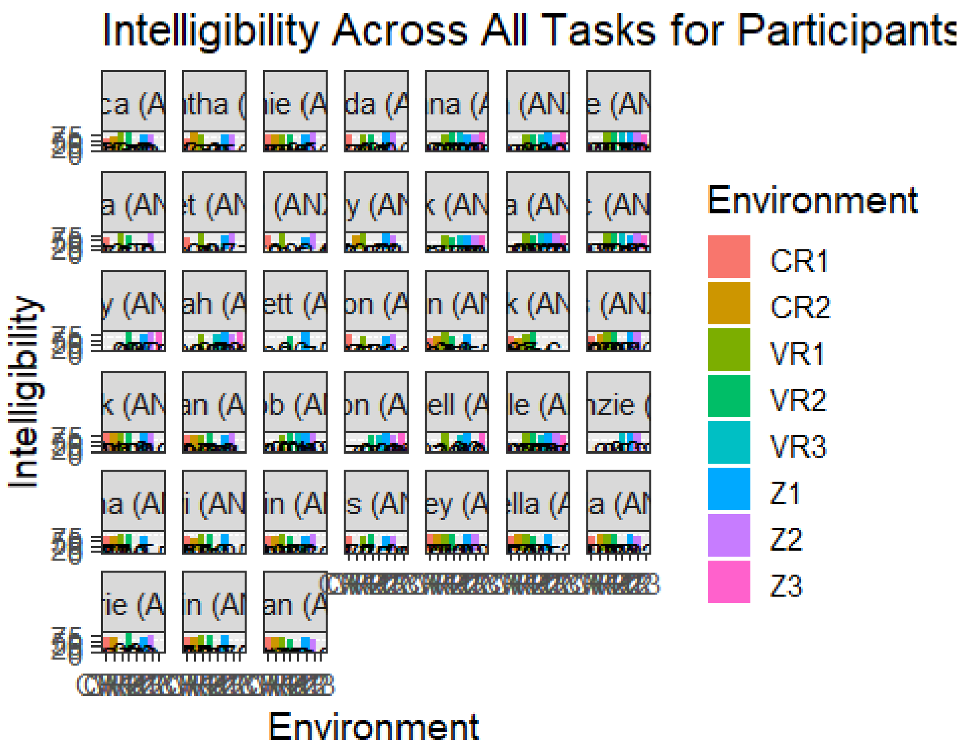
```
##  contrast  estimate   SE  df lower.CL upper.CL
##  CR1 - CR2  -2.3838 1.77 151    -7.81    3.044
##  CR1 - VR1 -10.4557 1.53 153   -15.16   -5.747
##  CR1 - VR2  -8.9746 1.58 154   -13.82   -4.134
##  CR1 - VR3  -9.5480 2.16 168   -16.19   -2.911
##  CR1 - Z1   -9.5351 1.52 155   -14.21   -4.861
##  CR1 - Z2   -9.8529 1.59 156   -14.73   -4.977
##  CR1 - Z3   -9.0488 2.23 166   -15.89   -2.208
##  CR2 - VR1  -8.0718 1.67 154   -13.21   -2.938
##  CR2 - VR2  -6.5908 1.70 155   -11.82   -1.364
##  CR2 - VR3  -7.1642 2.26 167   -14.11   -0.221
##  CR2 - Z1   -7.1513 1.66 155   -12.24   -2.062
##  CR2 - Z2   -7.4690 1.73 157   -12.78   -2.158
##  CR2 - Z3   -6.6650 2.33 165   -13.81    0.478
##  VR1 - VR2   1.4810 1.42 152    -2.88    5.838
##  VR1 - VR3   0.9076 1.97 161    -5.14    6.953
##  VR1 - Z1    0.9206 1.35 151    -3.22    5.058
##  VR1 - Z2    0.6028 1.42 152    -3.75    4.955
##  VR1 - Z3    1.4069 2.04 160    -4.86    7.671
##  VR2 - VR3  -0.5734 2.00 162    -6.70    5.557
##  VR2 - Z1   -0.5604 1.39 151    -4.82    3.698
##  VR2 - Z2   -0.8782 1.46 153    -5.36    3.607
##  VR2 - Z3   -0.0742 2.06 159    -6.40    6.249
##  VR3 - Z1    0.0130 1.93 160    -5.92    5.948
##  VR3 - Z2   -0.3048 1.98 159    -6.37    5.763
##  VR3 - Z3    0.4992 2.34 151    -6.68    7.681
##  Z1 - Z2    -0.3178 1.38 151    -4.57    3.930
##  Z1 - Z3     0.4863 2.00 159    -5.67    6.641
##  Z2 - Z3     0.8040 2.05 158    -5.48    7.090
##
```

```
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 8 est
imates
```

```
confint(pairs(groupintell.emm))
```

```
##  contrast        estimate   SE   df lower.CL upper.CL
##  (ANX-) - (ANX+)   -1.811 1.81 34.6    -6.24     2.61
##  (ANX-) - ANX±      0.545 2.05 36.7    -4.46     5.55
##  (ANX+) - ANX±      2.355 2.25 36.1    -3.14     7.85
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 3 est
imates
```

```
#plotting intelligibility scores
require(ggplot2)
speechdata$Participant = factor(speechdata$Participant, levels =c("Jes
sica (ANX+)", "Samantha (ANX+)", "Melanie (ANX+)", "Amanda (ANX+)", "H
ashana (ANX+)", "Ella (ANX+)", "Katie (ANX+)", "Lucia (ANX+)", "Violet
(ANX+)", "Leo (ANX+)", "Brody (ANX+)", "Mark (ANX±)", "Talia (ANX±)",
"Eric (ANX±)", "Riley (ANX±)", "Hannah (ANX±)", "Scarlett (ANX±)", "Hu
dson (ANX±)", "Ethan (ANX±)", "Nick (ANX-)", "Iris (ANX-)", "Rick (ANX
-)", "Rohan (ANX-)", "Jacob (ANX-)", "Mason (ANX-)", "Mitchell (ANX-)"
, "Nicole (ANX-)", "McKenzie (ANX-)", "Selina (ANX-)", "Levi (ANX-)",
"Martin (ANX-)", "Chris (ANX-)", "Stacey (ANX-)", "Izabella (ANX-)", "
Layla (ANX-)", "Valerie (ANX-)", "Justin (ANX-)", "Morgan (ANX-)"))

ggplot(speechdata, aes(x = Environment, y = Intelligibility, fill = En
vironment)) + geom_bar(stat = "identity") + facet_wrap(~Participant) +
ggtitle("Intelligibility Across All Tasks for Participants")+ geom_tex
t(aes(x = Environment, y = Intelligibility, label = paste(Intelligibil
ity), vjust = 1.25)) + theme_bw(14)
```




```
#And finally fluency
#descriptive data
min(speechdata$FluencyRaw)

## [1] 10.66667

max(speechdata$FluencyRaw)

## [1] 43.33333

speechdata %>%
  group_by(Environment) %>%
  summarise(min = min(FluencyRaw, na.rm = TRUE),
            max = max(FluencyRaw, na.rm = TRUE),
            med = median(FluencyRaw, na.rm = TRUE))

## # A tibble: 8 x 4
##   Environment   min   max   med
##   <chr>       <dbl> <dbl> <dbl>
## 1 CR1          10.7  37.3  22
## 2 CR2          14    43.3  24.3
## 3 VR1          12.5  38    23.3
## 4 VR2          13.7  41    26
## 5 VR3          15    36.7  27
## 6 Z1           11.3  42.7  21
```

```
## 7 Z2           14    40    25
## 8 Z3           20.3  36    25.3

speechdata %>%
  group_by(Environment) %>%
  summarise(mean = mean(FluencyRaw, na.rm = TRUE),
            sd = sd(FluencyRaw, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)

## # A tibble: 8 x 7
##   Environment  mean    sd     n    se lower.ci upper.ci
##   <chr>       <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 CR1          22.0  7.39    23  1.54     18.8     25.2
## 2 CR2          25.5  8.86    18  2.09     21.1     29.9
## 3 VR1          23.5  6.62    33  1.15     21.2     25.9
## 4 VR2          26.6  7.96    30  1.45     23.6     29.5
## 5 VR3          26.9  7.66    12  2.21     22.0     31.7
## 6 Z1           22.2  7.45    36  1.24     19.7     24.7
## 7 Z2           25.0  6.31    30  1.15     22.7     27.4
## 8 Z3           26.5  5.48    11  1.65     22.8     30.2

speechdata %>%
  group_by(AnxietyGroup) %>%
  summarise(min = min(FluencyRaw, na.rm = TRUE),
            max = max(FluencyRaw, na.rm = TRUE),
            med = median(FluencyRaw, na.rm = TRUE))

## # A tibble: 3 x 4
##   AnxietyGroup   min   max   med
##   <chr>        <dbl> <dbl> <dbl>
## 1 ANX-          11.3  43.3  25.7
## 2 ANX+          10.7  36.7  22
## 3 ANX±          13.7  39    25.2

speechdata %>%
  group_by(AnxietyGroup) %>%
  summarise(mean = mean(FluencyRaw, na.rm = TRUE),
            sd = sd(FluencyRaw, na.rm = TRUE),
            n = n()) %>%
  mutate(se = sd / sqrt(n),
         lower.ci = mean - qt(1 - (0.05 / 2), n - 1) * se,
         upper.ci = mean + qt(1 - (0.05 / 2), n - 1) * se)
```

```
## # A tibble: 3 x 7
##   AnxietyGroup  mean    sd     n    se lower.ci upper.ci
##   <chr>        <dbl> <dbl> <int> <dbl>    <dbl>    <dbl>
## 1 ANX-          25.9  7.94    99 0.798     24.3     27.5
## 2 ANX+          21.7  6.02    56 0.804     20.1     23.3
## 3 ANX±          24.3  6.70    38 1.09      22.1     26.5
```

```
m_fluency = lmerTest:: lmer(FluencyRaw~Environment + AnxietyGroup + (1
|Participant), data = speechdata)
summary(m_fluency)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method
[
## lmerModLmerTest]
## Formula: FluencyRaw ~ Environment + AnxietyGroup + (1 | Participant
)
##    Data: speechdata
##
## REML criterion at convergence: 1157.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.35131 -0.56564 -0.06962  0.61442  2.64044
##
## Random effects:
##  Groups      Name        Variance Std.Dev.
##  Participant (Intercept) 33.37    5.777
##  Residual                17.63    4.198
## Number of obs: 193, groups:  Participant, 38
##
## Fixed effects:
##                   Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)        23.9530     1.6285  62.4136  14.709  < 2e-16 ***
## EnvironmentCR2      3.3790     1.3455 149.3924   2.511 0.013088 *
## EnvironmentVR1      1.6869     1.1688 149.9229   1.443 0.151030
## EnvironmentVR2      4.1446     1.2037 150.6585   3.443 0.000745 ***
## EnvironmentVR3      3.4914     1.6764 156.5538   2.083 0.038905 *
## EnvironmentZ1      -0.2008     1.1634 151.0169  -0.173 0.863190
## EnvironmentZ2       2.8233     1.2145 151.3140   2.325 0.021414 *
## EnvironmentZ3       3.4975     1.7231 155.4849   2.030 0.044081 *
## AnxietyGroupANX+   -4.2505     2.3039  34.9775  -1.845 0.073532 .
## AnxietyGroupANX±   -2.9088     2.5822  35.9508  -1.126 0.267421
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Warning in abbreviate(rn, minlength = 11): abbreviate used with non
-ASCII chars

##
## Correlation of Fixed Effects:

## Warning in abbreviate(rn, minlength = 6): abbreviate used with non-
ASCII chars

##             (Intr) EnvCR2 EnvVR1 EnvVR2 EnvVR3 EnvrZ1 EnvrZ2 EnvrZ3
AGANX+
## EnvrnmntCR2 -0.366
## EnvrnmntVR1 -0.423  0.492
## EnvrnmntVR2 -0.422  0.484  0.585
## EnvrnmntVR3 -0.340  0.344  0.480  0.470
## EnvirnmntZ1 -0.436  0.498  0.614  0.603  0.502
## EnvirnmntZ2 -0.412  0.468  0.590  0.576  0.488  0.609
## EnvirnmntZ3 -0.318  0.334  0.467  0.462  0.452  0.488  0.474
## AnxtyGrANX+ -0.516  0.018 -0.011  0.009  0.001 -0.002 -0.019 -0.010
## AnxtyGrANX± -0.442  0.012 -0.026 -0.030 -0.043 -0.039 -0.035 -0.065
0.328

fluency.emm <- emmeans(m_fluency, "Environment")
pairs(fluency.emm)

##  contrast  estimate   SE  df t.ratio p.value
##  CR1 - CR2 -3.37900 1.35 149  -2.511  0.1991
##  CR1 - VR1 -1.68688 1.17 150  -1.443  0.8358
##  CR1 - VR2 -4.14459 1.20 151  -3.441  0.0167
##  CR1 - VR3 -3.49140 1.68 156  -2.079  0.4333
##  CR1 - Z1   0.20080 1.16 151   0.172  1.0000
##  CR1 - Z2  -2.82334 1.22 151  -2.323  0.2881
##  CR1 - Z3  -3.49753 1.73 155  -2.026  0.4677
##  CR2 - VR1  1.69212 1.28 150   1.326  0.8878
##  CR2 - VR2 -0.76559 1.30 151  -0.589  0.9990
##  CR2 - VR3 -0.11240 1.76 156  -0.064  1.0000
##  CR2 - Z1   3.57980 1.27 151   2.823  0.0970
##  CR2 - Z2   0.55566 1.33 152   0.419  0.9999
##  CR2 - Z3  -0.11853 1.80 155  -0.066  1.0000
##  VR1 - VR2 -2.45771 1.08 150  -2.273  0.3154
##  VR1 - VR3 -1.80452 1.52 154  -1.190  0.9339
##  VR1 - Z1   1.88768 1.03 149   1.841  0.5932
##  VR1 - Z2  -1.13646 1.08 149  -1.053  0.9652
##  VR1 - Z3  -1.81065 1.57 153  -1.154  0.9433
##  VR2 - VR3  0.65319 1.54 154   0.424  0.9999
##  VR2 - Z1   4.34539 1.06 149   4.115  0.0016
##  VR2 - Z2   1.32126 1.11 150   1.186  0.9349
```

```
##  VR2 - Z3   0.64706 1.58 153   0.409  0.9999
##  VR3 - Z1   3.69221 1.49 153   2.484  0.2103
##  VR3 - Z2   0.66807 1.52 152   0.440  0.9998
##  VR3 - Z3  -0.00613 1.78 149  -0.003  1.0000
##  Z1 - Z2   -3.02414 1.05 149  -2.874  0.0854
##  Z1 - Z3   -3.69834 1.54 152  -2.403  0.2477
##  Z2 - Z3   -0.67419 1.57 152  -0.429  0.9999
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 8 estima
tes
```

```
groupfluency.emm <- emmeans(m_fluency, "AnxietyGroup")
pairs(groupfluency.emm)
```

```
##  contrast        estimate   SE   df t.ratio p.value
##  (ANX-) - (ANX+)     4.25 2.30 34.8   1.845  0.1702
##  (ANX-) - ANX±       2.91 2.58 35.8   1.126  0.5044
##  (ANX+) - ANX±      -1.34 2.84 35.5  -0.472  0.8848
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## P value adjustment: tukey method for comparing a family of 3 estima
tes
```

```
#Cohen's d calculated using Plonsky's calculator from workshop
confint(pairs(fluency.emm))
```

```
##  contrast  estimate   SE  df lower.CL upper.CL
##  CR1 - CR2 -3.37900 1.35 149   -7.517    0.759
##  CR1 - VR1 -1.68688 1.17 150   -5.281    1.908
##  CR1 - VR2 -4.14459 1.20 151   -7.847   -0.442
##  CR1 - VR3 -3.49140 1.68 156   -8.652    1.669
##  CR1 - Z1   0.20080 1.16 151   -3.378    3.779
##  CR1 - Z2  -2.82334 1.22 151   -6.559    0.912
##  CR1 - Z3  -3.49753 1.73 155   -8.801    1.806
##  CR2 - VR1  1.69212 1.28 150   -2.232    5.616
##  CR2 - VR2 -0.76559 1.30 151   -4.764    3.233
##  CR2 - VR3 -0.11240 1.76 156   -5.506    5.281
##  CR2 - Z1   3.57980 1.27 151   -0.318    7.478
##  CR2 - Z2   0.55566 1.33 152   -3.519    4.631
##  CR2 - Z3  -0.11853 1.80 155   -5.650    5.413
##  VR1 - VR2 -2.45771 1.08 150   -5.782    0.866
##  VR1 - VR3 -1.80452 1.52 154   -6.467    2.858
##  VR1 - Z1   1.88768 1.03 149   -1.264    5.040
##  VR1 - Z2  -1.13646 1.08 149   -4.456    2.183
```

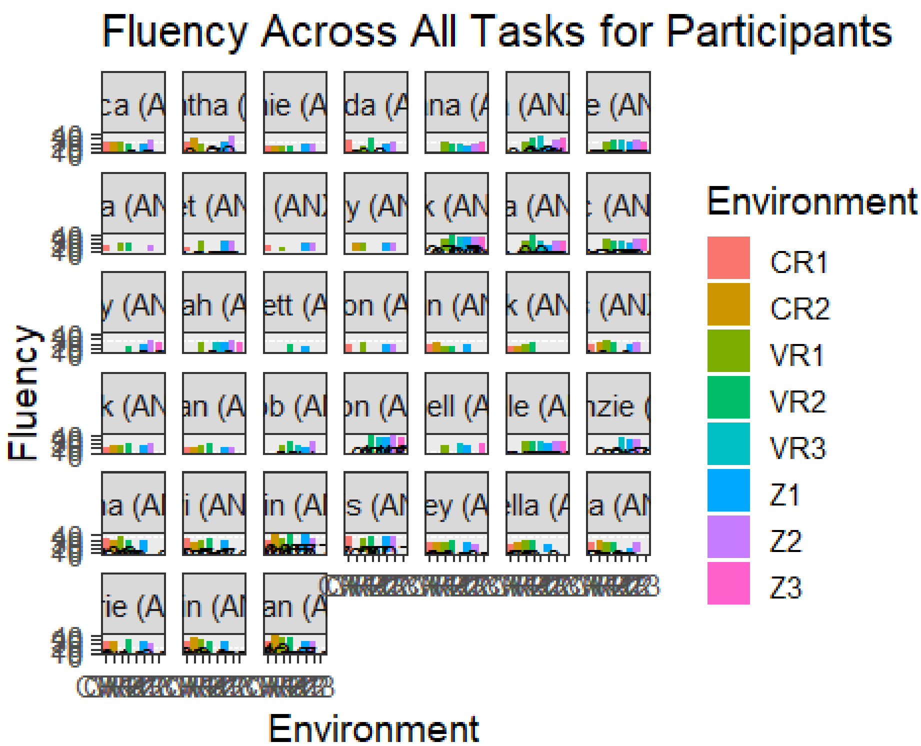
```
##  VR1 - Z3  -1.81065 1.57 153   -6.632    3.010
##  VR2 - VR3  0.65319 1.54 154   -4.078    5.384
##  VR2 - Z1   4.34539 1.06 149    1.099    7.592
##  VR2 - Z2   1.32126 1.11 150   -2.105    4.747
##  VR2 - Z3   0.64706 1.58 153   -4.218    5.512
##  VR3 - Z1   3.69221 1.49 153   -0.876    8.261
##  VR3 - Z2   0.66807 1.52 152   -3.995    5.331
##  VR3 - Z3  -0.00613 1.78 149   -5.479    5.466
##  Z1 - Z2   -3.02414 1.05 149   -6.259    0.211
##  Z1 - Z3   -3.69834 1.54 152   -8.429    1.033
##  Z2 - Z3   -0.67419 1.57 152   -5.501    4.152
##
## Results are averaged over the levels of: AnxietyGroup
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 8 est
imates
```

```
confint(pairs(groupfluency.emm))
```

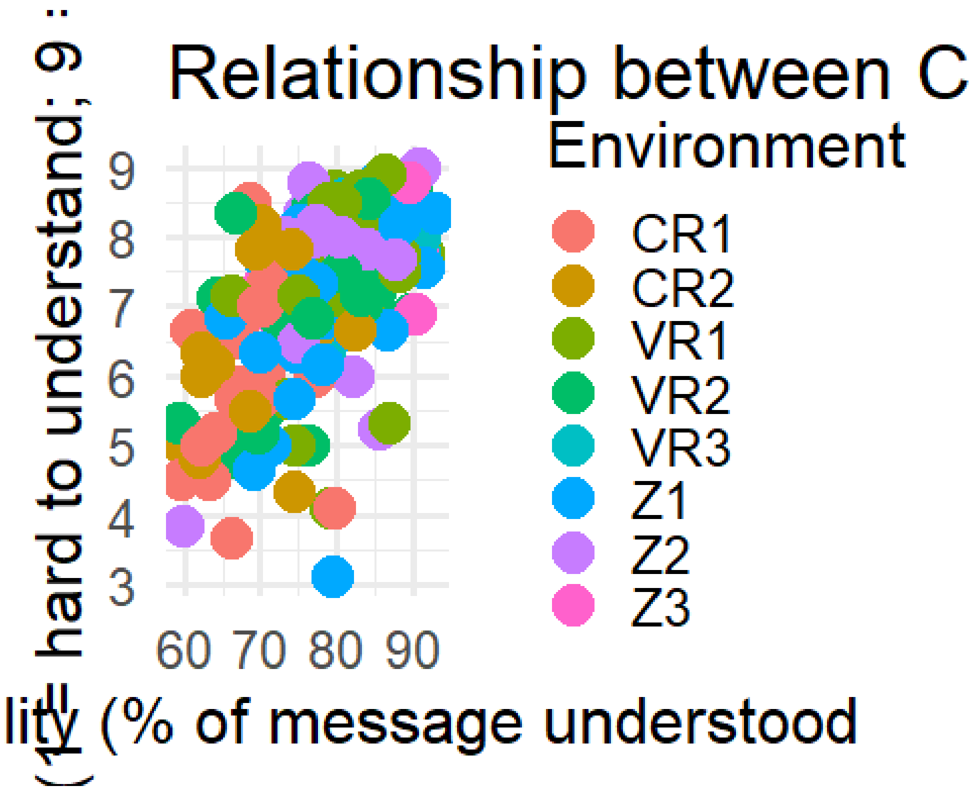
```
##  contrast        estimate   SE   df lower.CL upper.CL
##  (ANX-) - (ANX+)     4.25 2.30 34.8    -1.39     9.89
##  (ANX-) - ANX±       2.91 2.58 35.8    -3.40     9.22
##  (ANX+) - ANX±      -1.34 2.84 35.5    -8.29     5.61
##
## Results are averaged over the levels of: Environment
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## Conf-level adjustment: tukey method for comparing a family of 3 est
imates
```

```
#plotting fluency scores
require(ggplot2)
speechdata$Participant = factor(speechdata$Participant, levels =c("Jes
sica (ANX+)", "Samantha (ANX+)", "Melanie (ANX+)", "Amanda (ANX+)", "H
ashana (ANX+)", "Ella (ANX+)", "Katie (ANX+)", "Lucia (ANX+)", "Violet
(ANX+)", "Leo (ANX+)", "Brody (ANX+)", "Mark (ANX±)", "Talia (ANX±)",
"Eric (ANX±)", "Riley (ANX±)", "Hannah (ANX±)", "Scarlett (ANX±)", "Hu
dson (ANX±)", "Ethan (ANX±)", "Nick (ANX-)", "Iris (ANX-)", "Rick (ANX
-)", "Rohan (ANX-)", "Jacob (ANX-)", "Mason (ANX-)", "Mitchell (ANX-)"
, "Nicole (ANX-)", "McKenzie (ANX-)", "Selina (ANX-)", "Levi (ANX-)",
"Martin (ANX-)", "Chris (ANX-)", "Stacey (ANX-)", "Izabella (ANX-)", "
Layla (ANX-)", "Valerie (ANX-)", "Justin (ANX-)", "Morgan (ANX-)"))

ggplot(speechdata, aes(x = Environment, y = Fluency, fill = Environmen
t)) + geom_bar(stat = "identity") + facet_wrap(~Participant) + ggtitle
("Fluency Across All Tasks for Participants")+ geom_text(aes(x = Envir
```

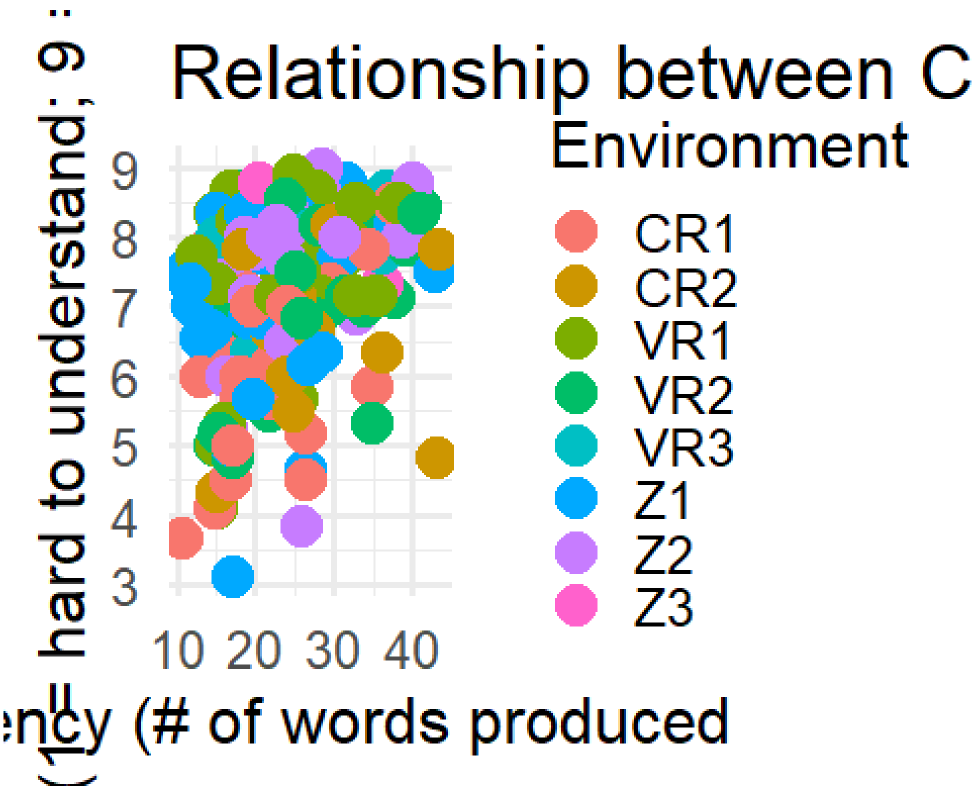
```
onment, y = Fluency, label = paste(Fluency), vjust = 1.25)) + theme_bw
(14)
```



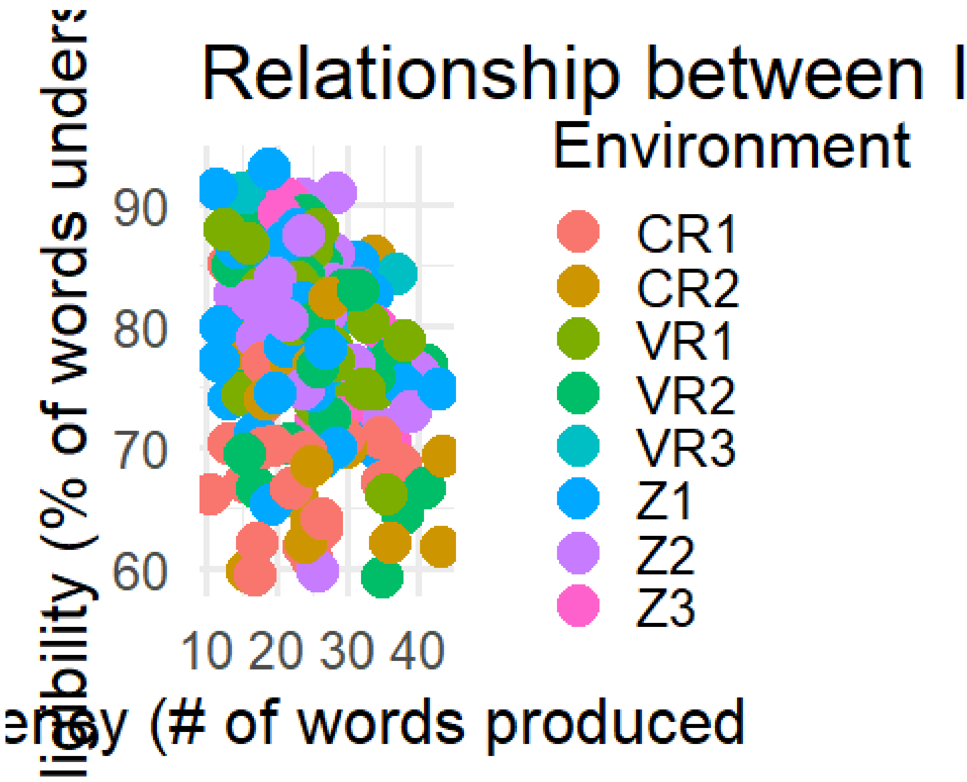

```
#relationship between the three
cor.test(speechdata$ComprehensibilityRaw, speechdata$IntelligibilityRa
w, method = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  speechdata$ComprehensibilityRaw and speechdata$Intelligibili
tyRaw
## t = 9.0277, df = 191, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4395986 0.6387827
## sample estimates:
##       cor
## 0.5468834

ggplot(speechdata, aes(x = IntelligibilityRaw, y = ComprehensibilityRa
w)) +geom_point(aes(color = Environment), size = 7) +ggtitle("Relation
ship between Comprehensibility and Intelligibility") +theme_minimal(24
) + labs(y = "Comprehensibility (1 = hard to understand; 9 = hard to u
nderstand", x = "Intelligibility (% of message understood")
```




```
cor.test(speechdata$ComprehensibilityRaw, speechdata$FluencyRaw, metho
d = "pearson")

##
##  Pearson's product-moment correlation
##
## data:  speechdata$ComprehensibilityRaw and speechdata$FluencyRaw
## t = 4.3391, df = 191, p-value = 2.316e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1653022 0.4228968
## sample estimates:
##       cor
## 0.2995487

ggplot(speechdata, aes(x = FluencyRaw, y = ComprehensibilityRaw)) +geo
m_point(aes(color = Environment), size = 7) +ggtitle("Relationship bet
ween Comprehensibility and Fluency") +theme_minimal(24) + labs(y = "Co
mprehensibility (1 = hard to understand; 9 = hard to understand", x =
"Fluency (# of words produced")
```



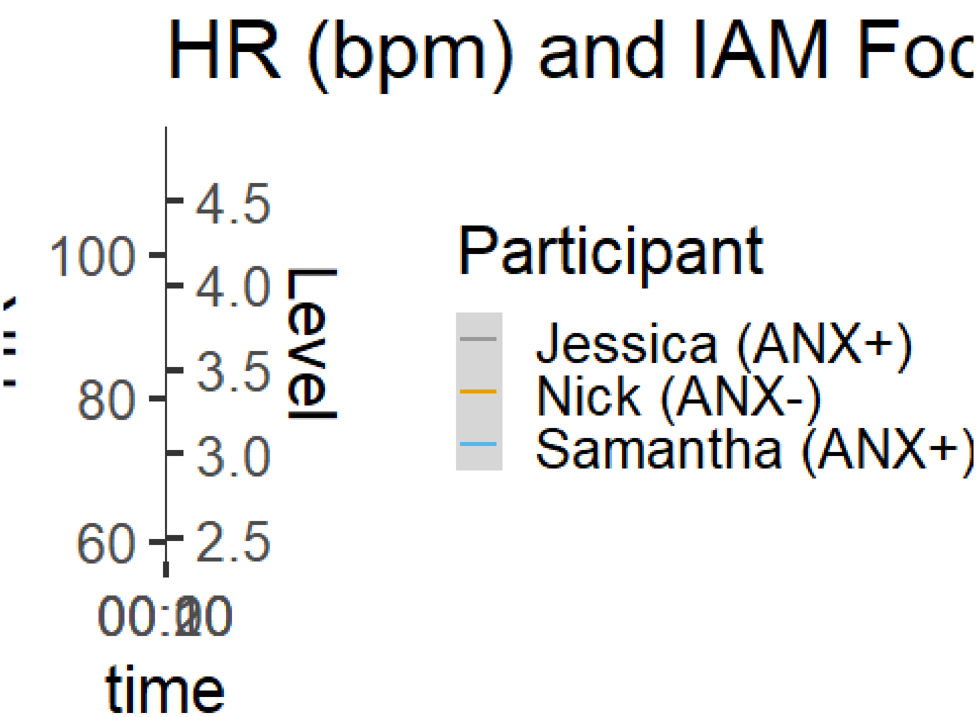

```
cor.test(speechdata$IntelligibilityRaw, speechdata$FluencyRaw, method
= "pearson")

##
##  Pearson's product-moment correlation
##
## data:  speechdata$IntelligibilityRaw and speechdata$FluencyRaw
## t = -3.5592, df = 191, p-value = 0.0004694
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.3773439 -0.1121043
## sample estimates:
##        cor
## -0.2493956

ggplot(speechdata, aes(x = FluencyRaw, y = IntelligibilityRaw)) +geom_
point(aes(color = Environment), size = 7) +ggtitle("Relationship betwe
en Intelligibility and Fluency") +theme_minimal(24) + labs(y = "Intell
igibility (% of words understood)", x = "Fluency (# of words produced"
)
```




```
#RQ4
CR1_FG1_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "CR1_FG1_IAM_Formatted2")

CR2_FG1_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "CR2_FG1_IAM_Formatted")

Zoom1_FG1_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "Zoom1_FG1_IAM")

Zoom2_FG1_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "Zoom2_FG1_IAM")

VR1_FG1_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "VR1_FG1_IAM")

VR2_FG1_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "VR2_FG1_IAM")

CR1_FG2_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "CR1_FG2_IAM")

CR2_FG2_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "CR2_FG2_IAM")
```

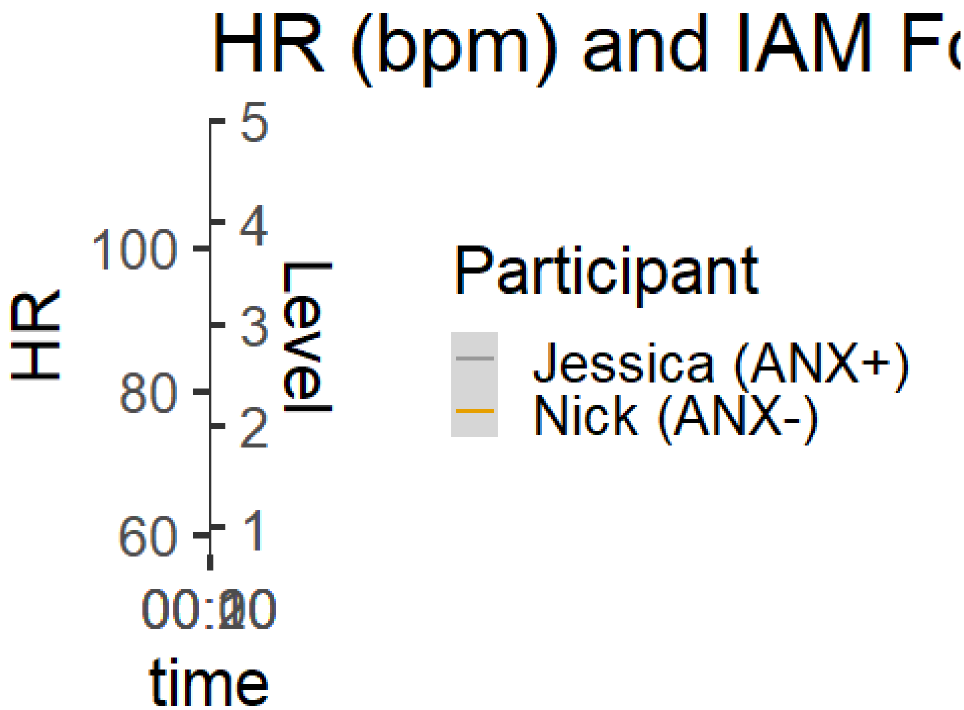
```
Zoom1_FG2_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "Zoom1_FG2_IAM")

Zoom2_FG2_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "Zoom2_FG2_IAM")

VR1_FG2_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "VR1_FG2_IAM ")

VR2_FG2_IAM <- read_excel("dissertation_data.xlsx",
    sheet = "VR2_FG2_IAM")

cbPalette <- c("#999999", "#E69F00", "#56B4E9", "#009E73", "#F0E442",
"#0072B2", "#D55E00", "#CC79A7")

#Mapping out IAM in time series based for FG1, CR1
#FG1, CR1
ylim.prim <- c(60, 115)
ylim.sec <- c(1, 7)

TEMP <- CR1_FG1_IAM$level #needed for coherent normalisation

# This is quite hacky, but it works if you want to set a boundary for
the secondary y-axis
fit = lm(b ~ . + 0,
         tibble::tribble(
           ~a, ~s,  ~b,
           1,  (ylim.sec[1] - mean(TEMP, na.rm = T))/sd(TEMP, na.rm =
T),  ylim.prim[1],
           1,  (ylim.sec[2] - mean(TEMP, na.rm = T))/sd(TEMP, na.rm =
T), ylim.prim[2]))

a <- fit$coefficients['a']
s <- fit$coefficients['s']


ggplot(CR1_FG1_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Jessica (ANX+)", "Nick (ANX-)", "Samantha (ANX+)"
))+  geom_smooth(aes(y = HR, color = participant, se = FALSE, size = 2
)) +geom_line(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick", size =.5)
+
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
```

```
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 1 Classroom 1")+ scale_si
ze(guide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 563 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 3775 rows containing non-finite values (stat_smoot
h).

## Warning: Removed 563 row(s) containing missing values (geom_path).

## Warning: Removed 3434 row(s) containing missing values (geom_path).
```



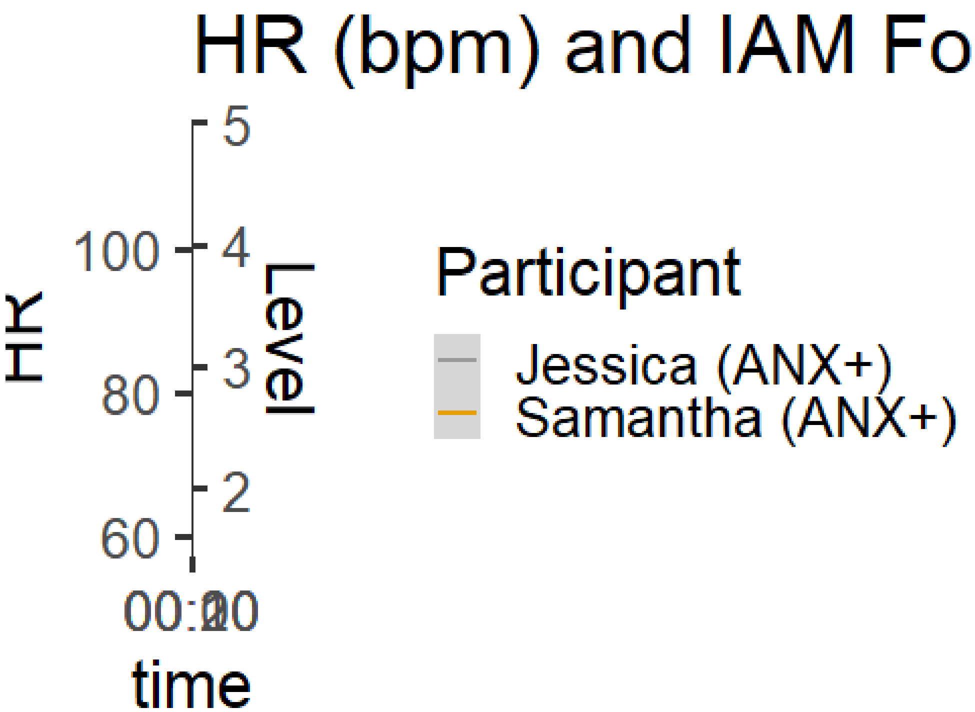

```
#FG1, CR2
TEMP <- CR2_FG1_IAM$level #needed for coherent normalisation
```

```
ggplot(CR2_FG1_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Jessica (ANX+)", "Nick (ANX-)"))+  geom_smooth(ae
s(y = HR, color = participant, se = FALSE, size = 2)) +geom_line(aes(g
roup = participant, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP,
na.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 1 Classroom 2")+ scale_si
ze(guide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 359 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 1836 rows containing non-finite values (stat_smoot
h).

## Warning: Removed 359 row(s) containing missing values (geom_path).

## Warning: Removed 1624 row(s) containing missing values (geom_path).
```



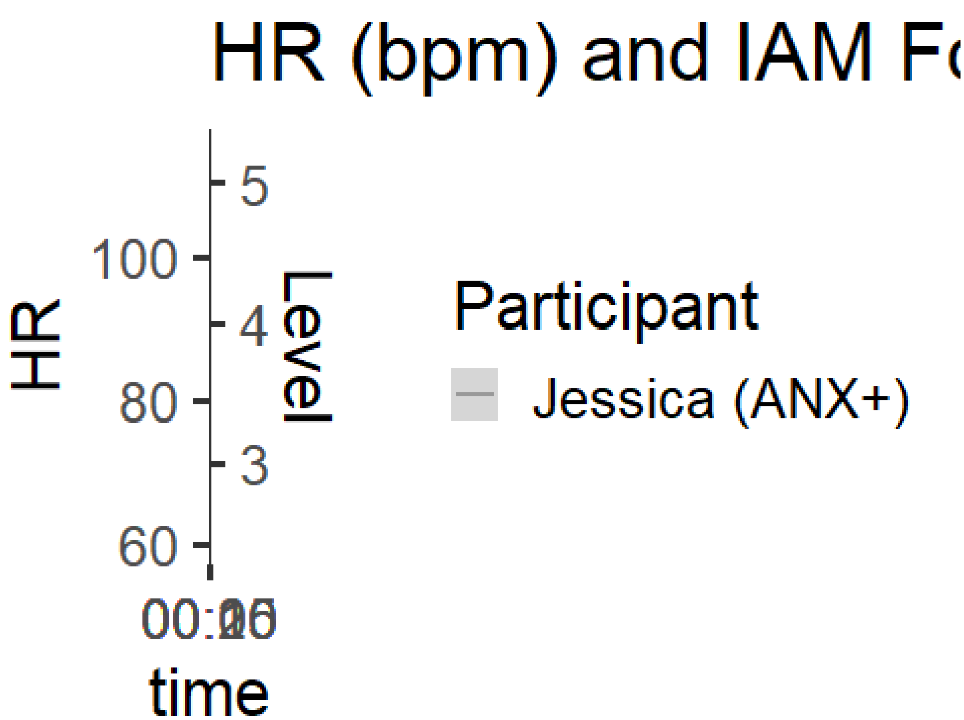

```
#FG1, Zoom1
TEMP <- Zoom1_FG1_IAM$level #needed for coherent normalisation

ggplot(Zoom1_FG1_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Jessica (ANX+)", "Samantha (ANX+)"))+  geom_smoot
h(aes(y = HR, color = participant, se = FALSE, size = 2)) +geom_line(a
es(group = participant, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TE
MP, na.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 1 Zoom 1")+ scale_size(gu
ide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'
```

```
## Warning: Removed 111 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 2145 rows containing non-finite values (stat_smoot
h).

## Warning: Removed 111 row(s) containing missing values (geom_path).

## Warning: Removed 1899 row(s) containing missing values (geom_path).
```

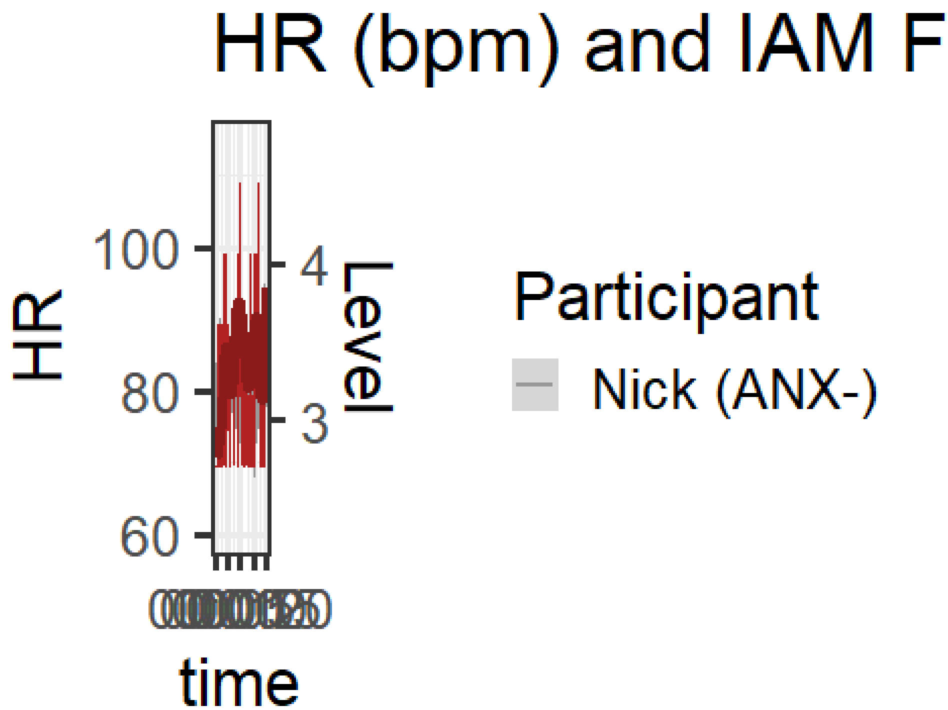



```
#FG1, Zoom2
TEMP <- Zoom2_FG1_IAM$level #needed for coherent normalisation

ggplot(Zoom2_FG1_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Jessica (ANX+)"))+  geom_smooth(aes(y = HR, color
= participant, se = FALSE, size = 2)) +geom_line(aes(group = participa
nt, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP, na.rm = T)) * s)
), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
```

```
                        sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 1 Zoom 2")+ scale_size(gu
ide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 104 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 392 rows containing non-finite values (stat_smooth
).

## Warning: Removed 56 row(s) containing missing values (geom_path).

## Warning: Removed 279 row(s) containing missing values (geom_path).

## Warning: Removed 1 rows containing missing values (geom_smooth).
```

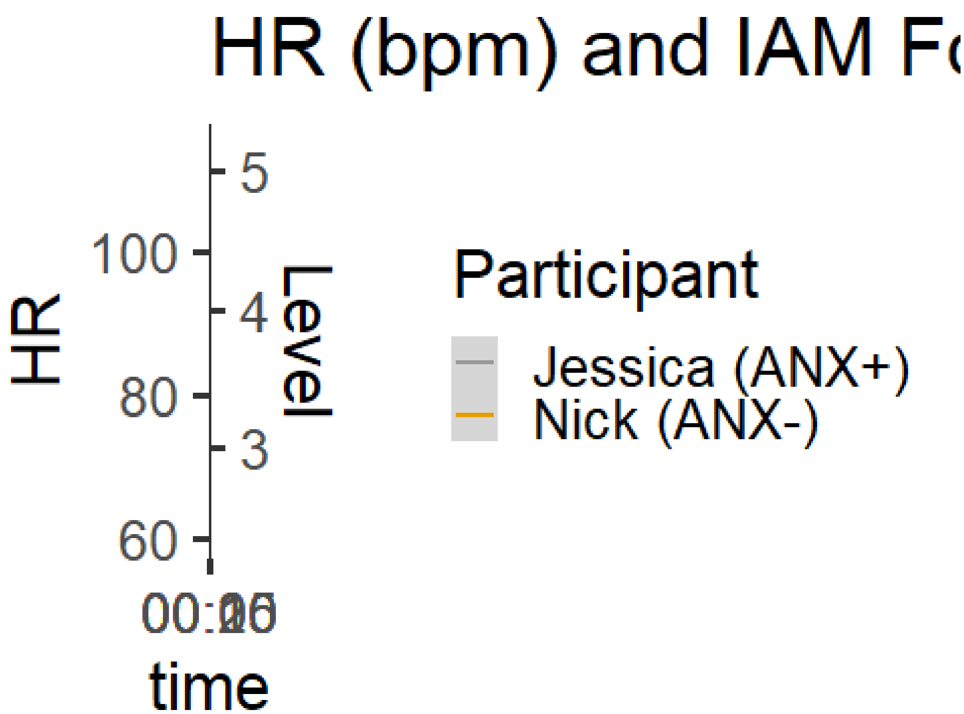


```
#FG1, VR1
TEMP <- VR1_FG1_IAM$level #needed for coherent normalisation

ggplot(VR1_FG1_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Nick (ANX-)"))+  geom_smooth(aes(y = HR, color =
participant, se = FALSE, size = 2)) +geom_line(aes(group = participant
, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP, na.rm = T)) * s) )
, color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 1 VR 1")+ scale_size(guid
e = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 245 rows containing non-finite values (stat_smooth
).

## Warning: Removed 39 row(s) containing missing values (geom_path).
```



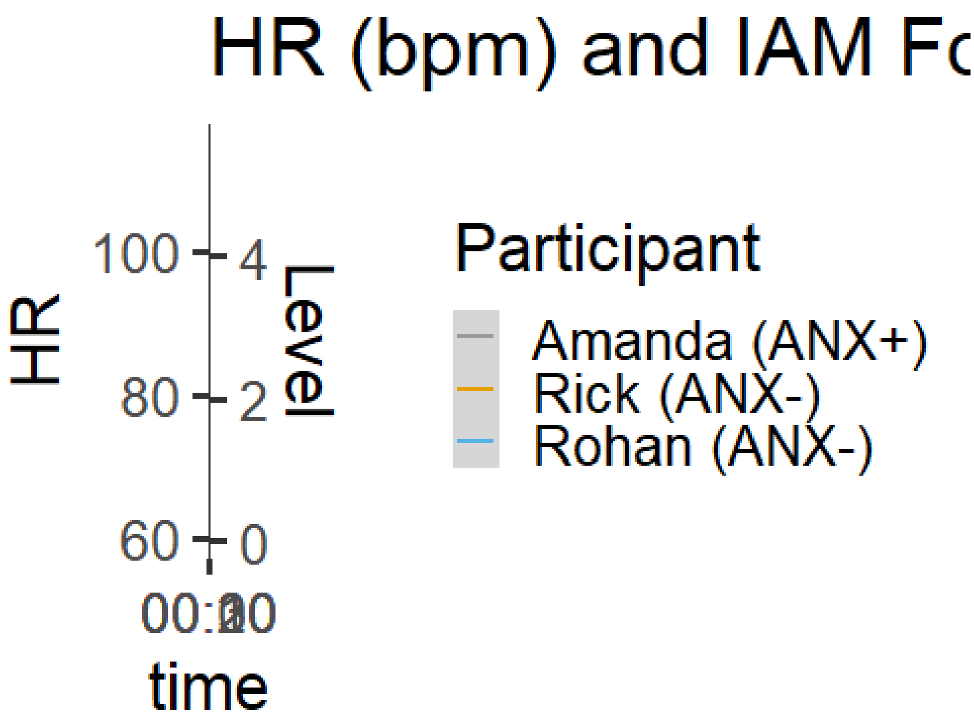

```
#FG1, VR2
TEMP <- VR2_FG1_IAM$level #needed for coherent normalisation

ggplot(VR2_FG1_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Jessica (ANX+)", "Nick (ANX-)"))+  geom_smooth(ae
s(y = HR, color = participant, se = FALSE, size = 2)) +geom_line(aes(g
roup = participant, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP,
na.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 1 VR 2")+ scale_size(guid
e = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'
```

```
## Warning: Removed 47 rows containing non-finite values (stat_smooth)
.

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 332 rows containing non-finite values (stat_smooth
).

## Warning: Removed 50 row(s) containing missing values (geom_path).
```




```
#FG2, CR1
TEMP <- CR1_FG2_IAM$level #needed for coherent normalisation

ggplot(CR1_FG2_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Amanda (ANX+)", "Rick (ANX-)", "Rohan (ANX-)"))+
geom_smooth(aes(y = HR, color = participant, se = FALSE, size = 2)) +g
eom_line(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na.rm =
T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                    limits=ylim.prim,
                    sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
```

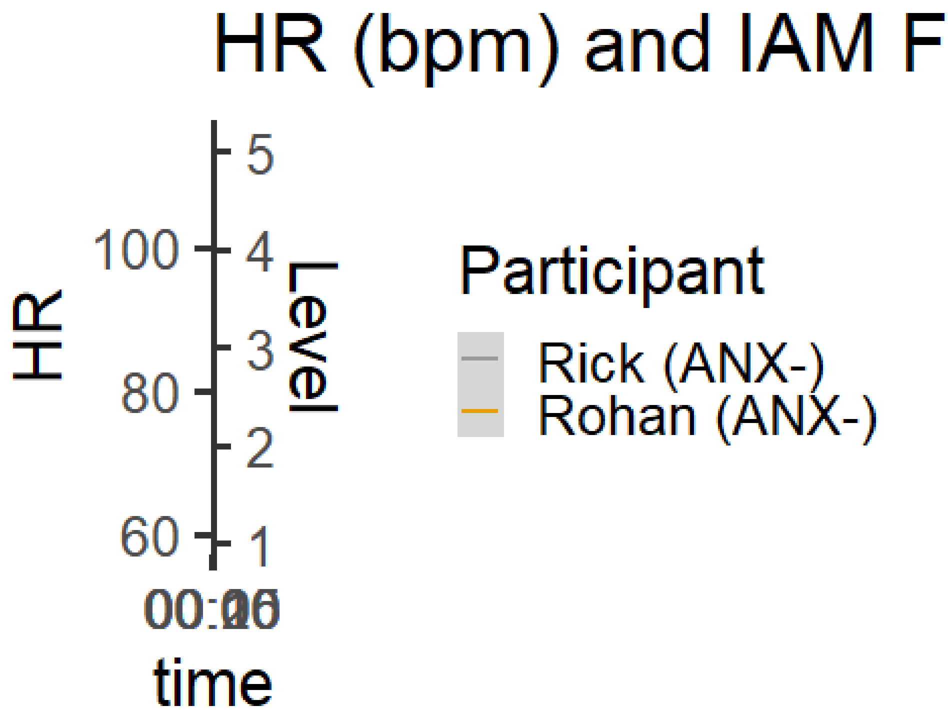
```
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 2 Classroom 1")+ scale_si
ze(guide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 530 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 3708 rows containing non-finite values (stat_smoot
h).

## Warning: Removed 109 row(s) containing missing values (geom_path).

## Warning: Removed 2028 row(s) containing missing values (geom_path).
```




```
#FG2, CR2
TEMP <- CR2_FG2_IAM$level #needed for coherent normalisation

ggplot(CR2_FG2_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
```

```
cipant", labels = c( "Rick (ANX-)", "Rohan (ANX-)"))+  geom_smooth(aes
(y = HR, color = participant, se = FALSE, size = 2)) +geom_line(aes(gr
oup = participant, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP, n
a.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 2 Classroom 2")+ scale_si
ze(guide = 'none')
```

```
## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 145 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 912 rows containing non-finite values (stat_smooth
).

## Warning: Removed 18 row(s) containing missing values (geom_path).

## Warning: Removed 484 row(s) containing missing values (geom_path).
```




```r
#FG2, Zoom1
TEMP <- Zoom1_FG2_IAM$level #needed for coherent normalisation

ggplot(Zoom1_FG2_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c( "Rohan (ANX-)"))+  geom_smooth(aes(y = HR, color
= participant, se = FALSE, size = 2)) +geom_line(aes(group = participa
nt, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP, na.rm = T)) * s)
), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 2 Zoom 1")+ scale_size(gu
ide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'
```

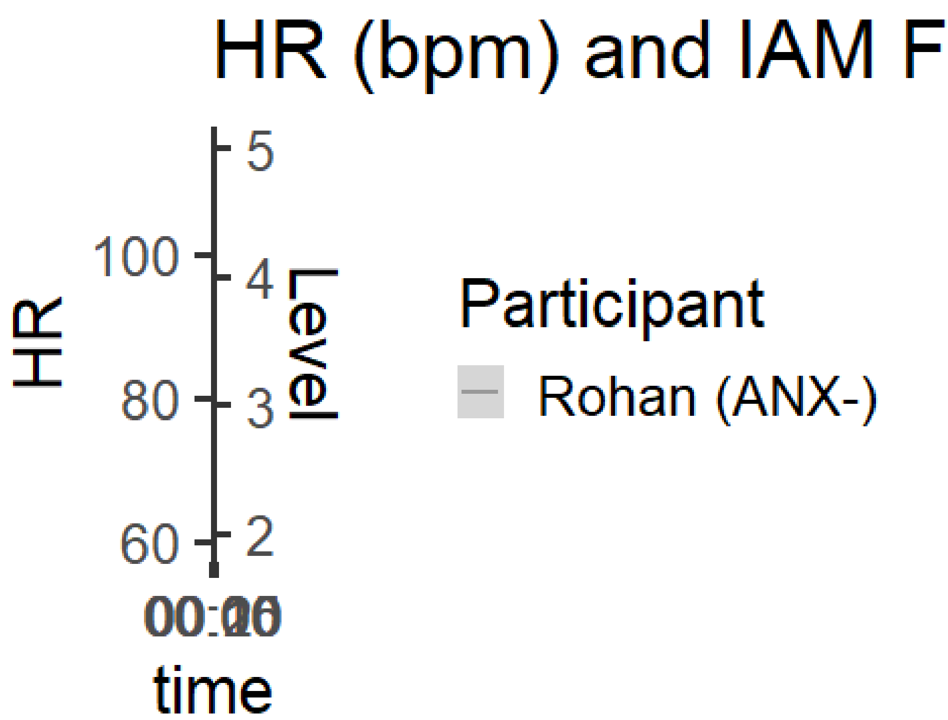
```
## Warning: Removed 86 rows containing non-finite values (stat_smooth)
.

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 248 rows containing non-finite values (stat_smooth
).

## Warning: Removed 10 row(s) containing missing values (geom_path).

## Warning: Removed 150 row(s) containing missing values (geom_path).
```




```
#FG2, Zoom2
TEMP <- Zoom2_FG2_IAM$level #needed for coherent normalisation

ggplot(Zoom2_FG2_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c( "Amanda (ANX+)", "Rick (ANX-)", "Rohan (ANX-)"))+
geom_smooth(aes(y = HR, color = participant, se = FALSE, size = 2)) +g
eom_line(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na.rm =
T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
```

```
                       sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group 2 Zoom 2")+ scale_size(gu
ide = 'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

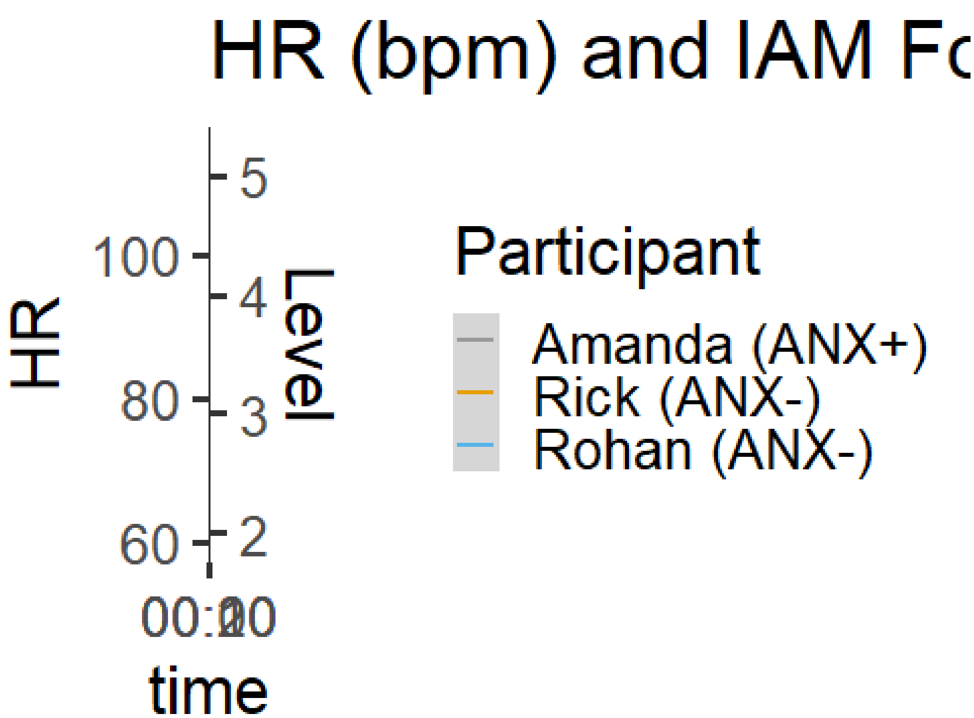
## Warning: Removed 1338 rows containing non-finite values (stat_smoot
h).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 1839 rows containing non-finite values (stat_smoot
h).

## Warning: Removed 68 row(s) containing missing values (geom_path).

## Warning: Removed 372 row(s) containing missing values (geom_path).
```




```
#FG2, VR1
TEMP <- VR1_FG2_IAM$level #needed for coherent normalisation
```

```
ggplot(VR1_FG2_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Rick (ANX-)", "Rohan (ANX-)"))+  geom_smooth(aes(
y = HR, color = participant, se = FALSE, size = 2)) +geom_line(aes(gro
up = participant, y = (a + ((TEMP - mean(TEMP, na.rm = T))/sd(TEMP, na
.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group VR1")+ scale_size(guide =
'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

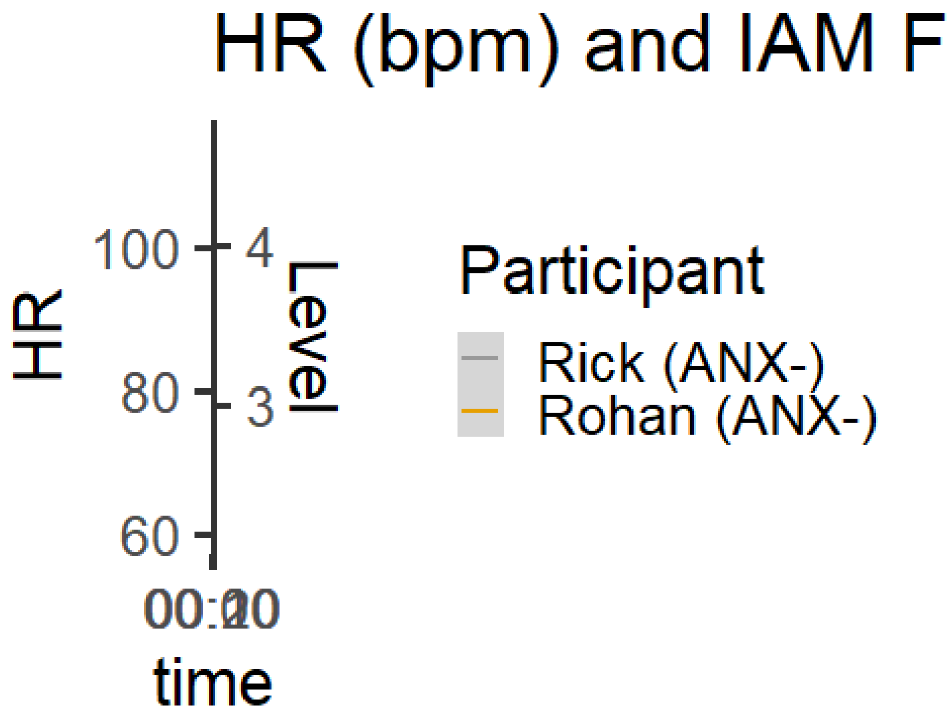
## Warning: Removed 420 rows containing non-finite values (stat_smooth
).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 808 rows containing non-finite values (stat_smooth
).

## Warning: Removed 2 row(s) containing missing values (geom_path).

## Warning: Removed 8 row(s) containing missing values (geom_path).
```




```
#FG2, VR2
TEMP <- VR2_FG2_IAM$level #needed for coherent normalisation

ggplot(VR2_FG2_IAM, aes(time, HR, color = participant)) +
  geom_line() +  scale_colour_manual(values = cbPalette, name = "Parti
cipant", labels = c("Rick (ANX-)", "Rohan (ANX-)", "Amanda (ANX+)"))+
geom_smooth(aes(y = HR, color = participant, se = FALSE, size = 2)) +g
eom_line(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na.rm =
T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick", size =.5) +
  geom_smooth(aes(group = participant, y = (a + ((TEMP - mean(TEMP, na
.rm = T))/sd(TEMP, na.rm = T)) * s) ), color = "firebrick4", se = FALS
E, size =2) +  scale_y_continuous("HR",
                     limits=ylim.prim,
                     sec.axis = sec_axis(~ (. - a) /( s * sd(TEMP, na.
rm = T)) + mean(TEMP, na.rm = T), name = "Level")) +
  theme(axis.title.y.right = element_text(colour = "red")) + theme_bw(
25) + ggtitle ("HR (bpm) and IAM Focus Group VR2")+ scale_size(guide =
'none')

## Warning: Ignoring unknown aesthetics: se

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'
```

```
## Warning: Removed 132 rows containing non-finite values (stat_smooth
).

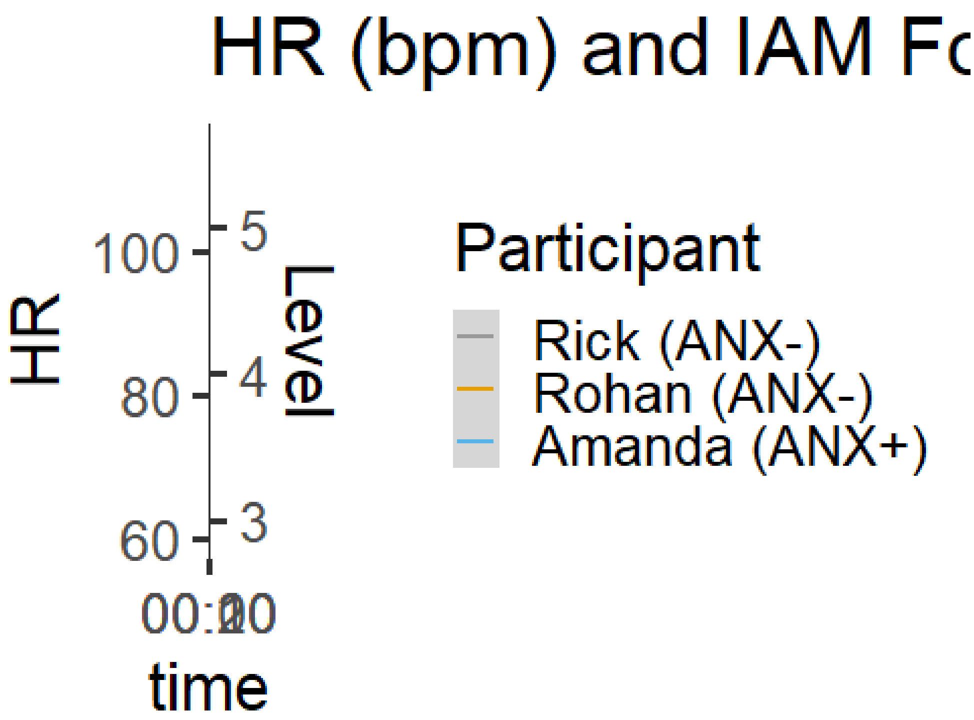
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs
")'

## Warning: Removed 1206 rows containing non-finite values (stat_smoot
h).

## Warning: Removed 44 row(s) containing missing values (geom_path).

## Warning: Removed 558 row(s) containing missing values (geom_path).

## Warning: Removed 6 rows containing missing values (geom_smooth).
```




```
```r
#RQ5 : Does presence relate to anxiety level?
vr_presence = diss_data %>% filter (EnvirOverall == "VR")
lm_presence = lmerTest::lmer(PostTask~Presence + (1|Participant), data
= vr_presence)
summary(lm_presence)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method
[
## lmerModLmerTest]
```
```

```
## Formula: PostTask ~ Presence + (1 | Participant)
##    Data: vr_presence
##
## REML criterion at convergence: 416.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.12762 -0.51316  0.04476  0.50001  1.70912
##
## Random effects:
##  Groups      Name        Variance Std.Dev.
##  Participant (Intercept) 24.80    4.980
##  Residual                12.54    3.541
## Number of obs: 68, groups:  Participant, 37
##
## Fixed effects:
##             Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  28.8536     2.7494 62.2576   10.49 2.12e-15 ***
## Presence     -0.7928     0.2743 56.5777   -2.89  0.00545 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr)
## Presence -0.940

lme.dscore(lm_presence, vr_presence, "lme4")

##                  t       df          d
## Presence -2.889941 56.57774 -0.7684156

confint(lm_presence)

## Computing profile confidence intervals ...

##                  2.5 %     97.5 %
## .sig01       3.409475  6.6971789
## .sigma       2.767260  4.6165741
## (Intercept) 23.261300 34.7183677
## Presence    -1.390291 -0.2346769

#yes, as presence increases, anxiety significantly decreases. i.e., th
e more immersed they feel in the virtual environment, the less anxious
they are. The same that you found during preliminary exam.
```

Including Plots

You can also embed plots, for example: ```

Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.