Feasibility of objective psychophysiological measurement in virtual reality with Inuit in Quebec

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Abstract (English)

Emotion regulation is reflected in the reactions of the body: phenotypical patterns of autonomic nervous system (ANS) arousal like cardiac and electrodermal activity. Some data would propose that individuals who have difficulties with emotion regulation (or disorders characterized by emotion dysregulation) have a generalized over-reactivity and dysregulated recovery even after some non-trauma-related cues. Thus, psychophysiological reactivity to height could be used as a paradigm to test the dysregulation of the ANS and provide an objective measure to characterize some aspects of emotion dysregulation. This paradigm could be useful in complementing psychometric measures of mental well-being and illness, especially in populations where reliability or safety of psychometric measurement is limited due to linguistic or cultural factors. For Inuit in Quebec, the concept of emotion regulation ties closely to their ability to adapt to the environment while recognizing limited control over it and keeping hopeful for the future (e.g., resilience). Inuit have indicated that common rating scales for psychopathology are not culturally sensitive. in this case, psychophysiological measurement could be useful for both momentary assessment and in treatment (e.g., biofeedback), and could relatively easily and inexpensively be implemented through the use of virtual reality (VR) and photoplethysmography (PPG) devices. In this thesis, I describe the integration, evaluation, and testing of a reactivity testing paradigm, which aims to be a more culturally sensitive measurement. I provide both qualitative and quantitative data towards this non-trauma psychophysiological reactivity testing paradigm that uses heights to evoke both subjective (self-reported) and objective (skin conductance response and heart rate) arousal. I describe the initial results of the usefulness and feasibility of the paradigm in a sample (n=16) of healthy participants. I also outline the protocol for a future randomized controlled trial, which will test the reactivity paradigm as a complementary outcome. This work is part of a larger co-design project with an Inuit advisory committee towards culturally sensitive methods in mental health services using digital technology.

Abstract (French)

La régulation des émotions se reflète dans les réactions du corps : schémas phénotypiques d'excitation du système nerveux autonome (SNA) comme l'activité cardiaque et électrodermale. Certaines données suggèrent que les individus qui ont des difficultés à réguler leurs émotions (ou des troubles caractérisés par une dysrégulation des émotions) ont une sur-réactivité généralisée et une récupération dysrégulée, même après des stimuli non liés à un traumatisme. Ainsi, la réactivité psychophysiologique à la hauteur pourrait être utilisée comme un paradigme pour tester la dysrégulation du SNA et fournir une mesure objective pour caractériser certains aspects de la dysrégulation des émotions. Ce paradigme pourrait être utile en complément des mesures psychométriques du bien-être et de la maladie mentale, notamment dans les populations où la fiabilité ou la sécurité des mesures psychométriques est limitée en raison de facteurs linguistiques ou culturels. Pour les Inuits au Québec, le concept de régulation des émotions est étroitement lié à leur capacité à s'adapter à l'environnement tout en reconnaissant un contrôle limité sur celui-ci et en gardant espoir pour l'avenir (par exemple, la résilience). Les Inuits ont indiqué que les échelles d'évaluation courantes pour la psychopathologie ne sont pas culturellement sensibles. Dans ce cas, la mesure psychophysiologique pourrait être utile à la fois pour l'évaluation momentanée et pour le traitement (par exemple, le biofeedback), et pourrait être relativement facile et peu coûteuse à mettre en œuvre grâce à l'utilisation de la réalité virtuelle (RV) et des appareils de photopléthysmographie (PPG). Dans cette thèse, je décris l'intégration, l'évaluation et le test d'un paradigme de test de réactivité, qui vise à être une mesure plus sensible culturellement. Je fournis des données qualitatives et quantitatives sur ce paradigme de test de réactivité psychophysiologique non traumatiqui, en utilisant les hauteurs pour évoquer l'excitation subjective (autodéclarée) et objective (réponse de conductance de la peau et fréquence cardiaque). Je décris les premiers résultats de l'utilité et de la faisabilité du paradigme dans un échantillon de n=16 participants en bonne santé. Je décris également le protocole d'un futur essai contrôlé randomisé, qui testera le paradigme de réactivité comme résultat complémentaire. Ce travail s'inscrit dans le cadre d'un projet plus vaste de co-conception avec un comité

consultatif Inuit, visant à mettre en place des méthodes culturellement sensibles dans les services de santé mentale à l'aide de la technologie numérique.

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I would like to thank and acknowledge the Inuit advisory committee's part in the co-design of the VR-CBT manual and protocol. Their passion and ways of knowing are the heart of the trial.

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I would like to thank my friends and family who have supported my thesis work. Thank you for reading my thesis over my shoulder as we co-work during a pandemic.

Content Warning: This thesis describes a distressing and potentially triggering incident involving medical racism to an Indigenous person (on page 95). It also discusses the impacts of trauma throughout and suicide rates (on pages 87 and onwards).

Contribution of Authors

Q.S is first author of all chapters in this thesis. Q.S. was involved ethics submissions for each project, recruitment, data collection, data analysis and authorship of manuscripts. Co-authors M.K., L.G.C and O.L. assisted in planning of the projects, ethics submission, participant recruitment, data collection (M.K.), data analysis (O.L.) and commenting of the manuscripts. Co-authors M.Y. and N.M. assisted in planning and initial ethics submissions for the projects. Co-authors D.J. and C.P. developed and monitored the bConnected Portal and were involved with the planning of the VR-CBT trial. Co-author S.B. developed the VR environments for use in both projects, wrote the VR-CBT treatment manual, consulted on several queries during my thesis work, and was involved in the planning of the VR-CBT trial.

Introduction

What is emotion regulation?

The body reflects the ability to regulate emotions. In response to external or internal stimuli, the body's autonomic nervous system activates. It modulates heart rate, respiration, and other bodily functions. Emotion regulation involves accepting, being aware, and having clarity over one's emotions. Emotion regulation also means controlling impulses, exacting goal-directed behaviour, and using regulation strategies (K. L. Gratz & L. Roemer, 2004). If there are difficulties with emotion regulation, it displays in psychophysiological responses. Accordingly, individuals with low emotion regulation scores show signs of general arousal in their everyday lives: having changes in/ higher heart rate (Ottaviani et al., 2016; Thuillard & Dan-Glauser, 2021) and higher systolic and diastolic blood pressure (Ottaviani et al., 2016). When they react to stimuli, they show lower heart rate variability (Berna, Ott, & Nandrino, 2014; Holzman & Bridgett, 2017; Visted et al., 2017; Williams et al., 2019), increased skin conductance response (Griffin & Howard, 2020; Webb, Miles, & Sheeran, 2012) and longer cardiac vagal recovery (Berna et al., 2014). Components of emotion regulation have large effect sizes on heart rate, systolic blood pressure and diastolic blood pressure (Busch, Possel, & Valentine, 2017).

Problems in emotion regulation are considered a transdiagnostic risk factor (Cludius, Mennin, & Ehring, 2020). Emotion regulation skills are often improved following psychotherapy even if they were not explicit therapy targets (Gratz, Weiss, & Tull, 2015). As such, theories link autonomic arousal to emotion regulation, such as the Neurovisceral Integration Model (Thayer, Hansen, Saus-Rose, & Johnsen, 2009; Thayer & Lane, 2000)and Polyvagal Theory (Porges, 2018). These models explain emotion regulation in terms of a vagally-mediated, bi-directional link between psychology and physiology. They posit that the underlying mechanisms of anxiety and post-traumatic stress disorders are dis-inhibited or defensive regulatory mechanisms (Porges, 2018; Thayer et al., 2009; Thayer & Lane, 2000).

How is emotion regulation related to Inuit resilience, culture, and mental health?

Strengthening resilience and mental well-being has gained urgency among Indigenous groups in Quebec, including Inuit (*Montreal urban aboriginal health needs assessment*, 2012). Inuit resiliency is rooted in an adaptability to the environment, recognition of "human limitation" (L. J. Kirmayer, S. Dandeneau, E. Marshall, M. K. Phillips, & K. J. Williamson, 2011) and hopefulness for the future (L. J. Kirmayer et al., 2011). The ability to *regulate one's emotions* and adapt are essential to individual and community resilience (L. J. Kirmayer et al., 2011). In the 2012 Montreal Urban Indigenous Health Needs Assessment, around 25% of survey respondents reported poor health, and respondents indicated an average score of 6 (out of 10) in an item that assessed the balance between four domains of health: physical, mental, spiritual, emotional. Feeling anxious or depressed was the most commonly reported problem, reported among 56% of Inuit respondents (*Montreal urban aboriginal health needs assessment*, 2012).

A strong community, family, and interpersonal relationships are often crucial to Inuit as part of resilience (L. J. Kirmayer et al., 2011). Still, adversity can challenge these supportive factors. Inuit, particularly in the North, experience household over-crowding at higher rates (Hansen, Larsen, Bjerregaard, & Riva, 2020; Kohen, Bougie, & Guevremont, 2015). The prevalence of mental health concerns among Inuit is also due to settler colonialism, which has both a historical and current traumatic influence on resilience—a complex and intergenerational process with well documented adverse impacts into the second and possibly third-generation (O'Neill, Fraser, Kitchenham, & McDonald, 2018; Paradies, 2016). Inuit communities also have diminished food security (e.g., healthy traditional foods like caribou and arctic char) access to the land due, which can invoke disconnection from culture and well-being. Equally, a trauma impacts parenting and interpersonal relations, having intergenerational effects on mental health conditions (Aguiar & Halseth, 2015; O'Neill et al., 2018). Resultingly, there is a strain on systems of accessing resilience and well-being. Having difficulties in emotion regulation (or strained resilience) usually means a person will also have more mental health concerns (Kraiss, Ten Klooster, Moskowitz, & Bohlmeijer, 2020)

How does emotion regulation factor into measurement and intervention with Inuit service users?

Though cultural competency allows for somewhat more accessible and adequate health care (Kirmayer, 2012), racism and inequities are still prevalent in Indigenous health users' experiences (Allan & Smylie, 2015). Cultural competency means providing competent cross-cultural care and responding to diverse values and needs (Betancourt, 2003; Ruben, 1989). Nevertheless, even the most basic necessity for mental health care, psychological measurement, is lacking. Many measures are developed within Western cultural contexts and the biomedical tradition and should not be used for a multi-cultural general population.

For example, Kanien'kéha (Mohawk) and Inuit in Quebec indicated that self-rating measures for depression are not culturally sensitive (Gomez Cardona et al., 2021). In other words, the scales were not accessible to the individual/group based on an understanding, respect, and awareness of self and others (Foronda, 2008). Though that particular study explicitly focused on depression scales, its findings may apply to other symptom-based measures in psychiatry, which involve numeric rating of feelings and a self-evaluative process and may lack the cultural sensitivity among several subgroups of the general population. In the same study, the Growth and Empowerment Measure (GEM) was well-accepted due to its focus on "supportive factors," as well as features that enhanced cultural sensitivity (e.g., non-numeric rating scale) and the possibility of cultural adaptation (Gomez Cardona et al., 2021).

Even interview schedules, such as the Diagnostic and Statistical Manual fifth edition (DSM-V), which is somewhat advantageous since it encourages a "supportive encounter," are ill-equipped for multi-cultural settings. The DSM-V provides a cultural formulation for diagnosis with the client's cultural context in mind, accounts for variation in some of the diagnostic criteria, and elaborates cultural concepts of distress (American Psychiatric Association, 2013). Besides focusing on a diagnosis not fitting with multi-cultural ideals of mental well-being, the critiques of latest version of the DSM are that it does not incorporate enough cultural sensitivity and potentially creates an ethnocultural divide among care providers. Using the DSM ineffectively could mean that culture is over-emphasized with some clients and not others (Bredstrom, 2019).

Psychophysiology Terms	Definitions (abbreviations)
• biofeedback	• process of rapidly feeding back physiological metrics to an individual, sometimes to change thoughts, behaviours, or physiology
• photoplethysmography	• detection of light absorption and reflection determined by hemoglobin at the site (e.g., dilation of arteries) (PPG)
• Pulse Rate Variability	• A similar metric to heart rate variability (HRV), measures the variability of systolic peaks in time and frequency domains
• Heart Rate Variability	• Variation in inter-beat intervals (IBI) in both time (e.g., standard deviations) and frequency (low:0.04–0.15 Hertz or high: 0.15–0.4 Hertz) domains
• Electrodermal activity	• Electrical currents generated between two sites, reflecting sweat gland activity (increased conductance with water)

Table 1: Psychophysiology: important terms

How can technology help provide culturally sensitive care?

More objective measures of psychological distress and well-being are becoming popular both in momentary assessment (e.g., biofeedback) and treatment (e.g., biofeedback training and bio-cueing) (McCraty & Shaffer, 2015; Ter Harmsel et al., 2021). By definition, biofeedback is a process of rapidly "feeding-back" physiological responses, such as heart rate, to a client to change thoughts and reactions and improve health (Schousboe et al., 2018) (**Table 1**). As psychiatry continues its search for biomarkers, there is some evidence for the reliability of psychophysiological responses also in demonstrating clinical outcomes (Yang, Mady, & Linnaranta, 2021).

The autonomic nervous system regulates several of the human body's "automatic" processes, such as heart and sweat gland functioning, and interacts with cognitions and emotions (Critchley, Eccles, & Garfinkel, 2013). For instance, presenting with a lower HRV (i.e., the regularity of time between subsequent heartbeats, also known as HRV) and higher resting blood pressure are linked with the presence of post-traumatic stress disorder (PTSD) (Shaffer & Ginsberg, 2017a; Yang et al., 2021). Decreased skin conductance response, a metric of electrodermal activity indicating peak levels of sweat gland reactivity to stimuli (Greco, Valenza & Scilingo, 2016), and resting and heart rate reactivity, and increased HRV are linked to clinical treatment and sometimes to psychometric measures of PTSD (Yang et al., 2021). Equally, metrics like HRV and skin conductance change along with emotion regulation following treatment (Balzarotti, Biassoni, Colombo, & Ciceri, 2017; El Khoury-Malhame, Reynaud, Beetz, & Khalfa, 2017; McCraty & Shaffer, 2015; Shepherd & Wild, 2014; Tupak et al., 2014). See **Table 2** for a detailed analysis of the advantages and disadvantages of both subjective and objective measurements.

Measure (and example)	**Properties**	**Advantages**	**Disadvantages**
Self-reports (e.g., rating-scales)	• Usually, brief • Self-evaluation • Numeric or categorical rating • Focus on discrete constructs • Categorical or dimensional results • Compare to a reference group/result	• Brevity • Simplicity of use and interpretation	• Few culturally sensitive measures exist • Overly categorical • Less informative for clinical work • Potential cognitive or memory biases • Focus on a specific problem, often symptoms
Interviews (e.g., semi-structured interview)	• Tend to be lengthier • Involve self-description/evaluation, clinician evaluation, sometimes evaluation by family or others • Dichotomous (present/not present) checklists or sum score	• Assessment involves a « supportive encounter ». • Can develop illness narratives and provide rich information	• Reliant on therapeutic alliance • Possible micro-aggressions, miscategorization, misunderstanding of cultural idioms of distress/well-being

	• Robust/descriptive information • Compare to a reference group or provide an individualized assessment		• Cultural sensitivity is lacking in many interview guides • Focus on a specific problem, often diagnosis focused
Objective tests (e.g., psychophysiological indices)	• Ultra short term (>5), short-term and up to 24hour measurement • Evaluation by a clinician to reference norms • Analysis of trends, averages, and changes • Objective information about physiological state allowing for interpretation of psychological state • Compare to a reference group/value or provide an individualized assessment	• Multiple psychological constructs, including emotion regulation, can be studied • Situations that are physiologically arousing are not always culturally bound • Interpretable by both health care providers and users	• Cultural sensitivity not yet known • Contact with the body may be intrusive • Giving internal information about the body which may be intrusive

Table 2: Examples of measurement in a culturally informed context

Several methods can implement biofeedback in clinical work, including, most recently, virtual reality (VR). A head-mounted device (i.e., headset) immerses the user into a digital reality that can simulate a scene from reality. Users may observe image or auditory changes analogous to the internal environment (e.g., rapid auditory feedback to mirror heart rate). In a clinical setting, biofeedback can occur during the practice of emotional or other skills to induce awareness or change of the internal state. Though only equally as clinically effective as active control conditions, combining biofeedback and virtual reality has several advantages (Tolin, Davies, Moskow, & Hofmann, 2020). VR and biofeedback can increase motivation, attention, presence, and perceived restorative properties of the intervention, as well as promote healthy psychophysiological responses, tailor the intervention to the individual, and boost ecological validity (Blum, Rockstroh, & Goritz, 2019; Desirée Colombo et al., 2019; Rockstroh, Blum, & Göritz, 2020).

Moreover, technology like biofeedback and VR are auspicious for resilience-based approaches (i.e., emotion regulation) (Desirée Colombo et al., 2019). All these other benefits still considered; combining VR and biofeedback could also enhance cultural sensitivity. Biofeedback training does not necessitate a focus on any particular disorder or symptom and can boost emotion-regulation approaches. Given the literature in this area, and focus groups conducted by our research group in planning these projects, emotion regulation is well-accepted, and there is an interest in technologies in mental health (Gomez-Cardona et al., *in preparation*).

Thesis rationale: Why psychophysiology? Why VR? Why Inuit?

Despite mental well-being and illness being a primary challenge, Inuit in Canada have models of coping and are resilient (L. J. Kirmayer et al., 2011; M. Morris & Crooks, 2015). Inuit resilience may be attributable to being hopeful and adaptive to the future (L. J. Kirmayer et al., 2011). Emotion regulation-based approaches could fit well with this worldview. With concerns about cultural sensitivity largely unaddressed among many conventional measurements and interventions, moving into health technology and objective measures may be a promising approach. For one, objective measurements are linked to emotion regulation and also to clinical outcomes. Combining objective physiological measurements (i.e., biofeedback) with VR also opens opportunities for increased benefits like reduced cognitive strain during therapeutic encounters and cultural sensitivity. I provide an initial response to the usefulness and feasibility of an objective psychological measurement paradigm designed for this purpose. The paradigm uses a universally arousing stimulus, exposure to heights, to evoke and measure psychological arousal. Meanwhile, I expand on future prospects of digital mental health technologies, introducing a culturally-adapted virtual reality cognitive behavioural therapy for Inuit.

Literature Review

Why height exposure?

Psychophysiology indicates treatment response

A recent systematic review on psychophysiological phenotypes and changes in psychophysiological metrics from trauma and treatment for trauma confirmed the utility of objective markers as outcome measures (Yang et al., 2021). Several metrics, including heart rate and skin conductance, had phenotypes correlated with subjective reports, and reflected changes in primary difficulties, such as emotion regulation, in treatment outcome. Thus, there is support for psychophysiological measures when investigating mental health. However, out of the total of n=22 reviewed articles, several involved direct trauma-cueing as part of treatment or in the measurement of outcomes.

Current methods of arousal induction are inappropriate

One article reviewed n=61 studies that used virtual reality (VR) to induce moods in healthy participants. The authors found that VR effectively induces stress, anxiety, emotional arousal, and emotional valence(Bernardo, Bains, Westwood, & Mograbi, 2020). However, the authors remarked that nearly half of all studies did not use physiological markers and should be used in future studies to avoid the limitations of subjective measures. When collected, electrodermal activity and heart rate were the two most commonly used metrics in n=23 and n=21 studies, respectively.

Many stress, anxiety, emotional arousal/valence-changing paradigms could be triggering or be confounded. Commonly used stimuli are 1) social stimuli, 2) games or fictional scenarios (n= 9-11 studies each). The Trier Social Stress Task in VR, for example, would be a social stimulus, and a zombie-killing mission is an example of a VR game stimulus. The other studies used 1) realistic fear scenarios like emergencies (e.g., fire; n=3), 2) the dark (about three studies), 3) spiders (around two studies), 4) crime and 5) heights. The intensity of the scenarios ranged from intense (e.g., VR explosions, gunshot sounds, collapsing floors, aversive electrical stimuli, and analogue trauma) to day-to-day stress (e.g., job interviews or navigation tasks)(Bernardo et al., 2020).

The appropriateness of many of these stimuli would vary from person to person. For instance, a park after dark where figures of other people move in the distance can introduce memories of trauma or gender-based effects. Experiencing aversive electrical shocks, degrading emotional memories, explosions, gunshots, or fires are also probably too intense for use in the general population. These stimuli might introduce mistrust or discomfort in continuing for longitudinal measurement or treatment. Simple, universal mood-inducing paradigms that do not invoke trauma memories and moderate-intensity are needed.

Exposure to heights evokes arousal

Height exposure paradigms may respond to the current gaps in the literature on objective psychophysiological measurement. However, only one study included in the previous review (Bernardo et al., 2020) used height exposure as the stimulus (Seinfeld et al., 2015). In the study, Seinfeld et al., 2015, subjective measurements of state anxiety were significantly different in a group that just had height exposure (no other stimuli) than another group where music had a calming effect (Seinfeld et al., 2015). There were no significant effects of height on skin conductance level (SCL), other than at the floor level (lowest altitude) (Seinfeld et al., 2015).

Height exposure has been investigated in the context of stress resilience, using a sample of air traffic controllers and a control group. The air traffic controllers group achieved more cardiac allostasis, more bodily compensation to return to normal during stress, than the control group, reflecting higher levels of resilience (Cosic et al., 2019). More recently, virtual reality height exposure among healthy participants induced a more positive affect, greater presence in the immersion, and higher arousal and anxious behaviour levels than among controls (no height) (Kisker, Gruber, & Schone, 2021). Nevertheless, many of these studies specifically focused on a particular field (e.g., music) or group (e.g., occupational groups). However, when comparing healthy controls to patients with acrophobia (i.e., fear of heights), researchers have also remarked changes in heart rate and skin conductance level in both groups (Diemer, Lohkamp, Mühlberger, & Zwanzger, 2016).

The literature on height exposure in healthy controls is relatively minute, with mixed support for psychophysiological measures like SCL to indicate arousal (Diemer et al., 2016; Seinfeld et al., 2015). No studies to my knowledge report skin conductance response. Nonetheless, researchers have used virtual reality paradigms to induce emotional arousal and response to heights even among non-acrophobic controls (Bernardo et al., 2020; Cleworth, Chua, Inglis, & Carpenter, 2016; Cosic et al., 2019; Diemer et al., 2016).

Why psychophysiology?

Photoplethysmography devices are efficient and reliable

Photoplethysmography (PPG) devices are just one kind of "wearable" technology at the forefront of psychophysiological measurement. Typically, PPG sensors can be small, portable, non-intrusive, and non-expensive due to the simplicity of the technology and components (Ismail, Akram, & Siddiqi, 2021). The sensors include a light source and a photodetector, which measure blood volume pulse by capturing the reflected light from the measurement site. Since red blood cells absorb infrared light, less light reflects when more blood flow is at the site (i.e., increased blood volume). The signal composition includes a slowly varying component due to breathing, body temperature regulation and other processes, blood volume pulse dictated by the heart, scattered light not being absorbed by hemoglobin and a few sources of noise (e.g., outside illumination) (Blazek, 2021). We detect electrodermal activity when two electrodes placed on the skin generate electrical currents from sweat gland activity(Hugo F. Posada-Quintero & Ki H. Chon, 2020).

The PPG device positioned on the finger reliability reads both cardiac and electrodermal activity. PPG signals like pulse rate variability (PRV) from the finger produce signals which are more closely related to echocardiography than are other sites (e.g., wrist) (Nardelli, Vanello, Galperti, Greco, & Scilingo, 2020). Equally, the index finger's volar (or palmar) surface is among the most reliable sites for skin conductance measurement (Figner & Murphy, 2011). Increasingly, PPG devices are medical-grade, further assuring their quality (Nogueira et al., 2018). Thus, psychophysiology is easily accessible to the researcher and clinician through relatively inexpensive and straightforward technology.

Psychophysiology indicates emotion regulation

Psychological interventions can reliable use PPG devices to study changes in psychophysiology; for example, in studies aiming to improve emotion regulation abilities (Christou-Champi, Farrow, & Webb, 2015). In other studies, emotion regulation strategy use decreases heart rate and increases and decrease skin conductance (Griffin & Howard, 2020). For instance, in a study of medical students during a stressful simulation task (Harley, Jarrell, & Lajoie, 2019), emotional suppression was positively associated with skin conductance level. Meanwhile, in some other studies, strategies like reappraisal were negatively associated with skin conductance (Griffin & Howard, 2020). A meta-analysis of several emotion regulation strategies reported that expressive suppression has a "small negative effect on physiological indices of emotion regulation" (Webb, Miles, Sheeran, 2012, p.791). These findings become less apparent when considering more recent evidence, such as a meta-analysis by Zaehringer et al. (2020), which found little evidence of heart rate or skin conductance being associated with either suppression or reappraisal(Zaehringer, Jennen-Steinmetz, Schmahl, Ende, & Paret, 2020).

The seemingly opposing literature on emotion regulation and autonomic arousal is qualified somewhat by the study characteristics. Firstly, many of these studies focus on specific emotion regulation strategies, rather than emotion regulation as a general ability. In a model proposed by Gratz et al., 2004 emotion regulation is an ability which includes not only the use of strategies but also the ability to control impulses and accept emotions (K. L. Gratz & L. Roemer, 2004). Thus, strategy use is important, but it does not encompass all of the many aspects of emotion regulation. Furthermore, in many of the studies, researchers instructed participants how and when to regulate their emotions and induced them during tasks that sometimes lacked ecological validity, such as picture or movie clip tasks (Zaehringer et al., 2020). Lastly, methods of momentary assessment of emotion regulation are lacking, even as the literature in the area grows(D. Colombo et al., 2020). Many studies rely on self-rated ecological momentary assessments but do not use validated items or measure constructs adjacent to emotion regulation (e.g., items assessing mindfulness or attention).

It seems that psychophysiological measurement could be useful as ecological momentary assessment of emotion regulation if we identify the associated phenotypes and use reliable sensors. Heart rate and skin conductance are not associated with some emotion regulation strategies; therefore, a more robust assessment of emotion regulation is warranted. Many previous studies have measured only reappraisal or suppression and used skin conductance level (not response) as an indicator. One of the primary domains in post-traumatic stress disorder (PTSD) is difficulties in emotion regulation and is linked to skin conductance levels dependent on PTSD status (Pole, 2007; Yang et al., 2021).

To continue into objective measurements of emotion regulation, we must address some of the limitations of PPG. For one, PPG data is susceptible to motion artifacts, especially given many wearable sensors aim to have participants move while using the device (Nardelli et al., 2020). Nevertheless, to my knowledge, there are only two open-source packages to analyze PPG data (van Gent, Farah, Nes, & van Arem, 2018) and (Vest et al., *in press*). Both packages require knowledge of coding languages Python or Matlab and are not readily available for clinical settings. Some companies offering biosensor devices also offer mobile applications or programs which can process the data. Still, there are privacy issues, such as data storage or inaccessibility of the algorithms. A more robust and clinically oriented investigation into psychophysiological metrics and emotion regulation is warranted.

What is needed?

Collaboration with the group of interest

The people in Canada are multicultural—from the various communities of First Nations, Métis and Inuit to the many other cultural groups that have settled there. Nevertheless, psychiatry has continued the colonial tradition, marginalizing Indigenous and other communities as it centers its ideals and practices. We see this reflected in the psychiatry literature, where Western, Educated, Industrialized, Rich, and Democratic (WEIRD) samples are overrepresented (Henrich, Heine, & Norenzayan, 2010). Measures in psychiatry, too lack cultural sensitivity. Many self-reported measures have not been evaluated for acceptability despite their favourable psychometric properties (Gomez Cardona et al., 2021; Williamson et al., 2014).

These ignorances are easier to understand when we consider that psychiatry research has been *among* rather than *with* or *by* marginalized groups. This research typically takes the format of outsider researchers offering solutions for an issue without consultation or desire from the community for the intervention. Multiple frameworks explain how essential co-design or community-led projects are to research (Donetto, Pierri, Tsianakas, & Robert, 2015; Palmer et al., 2019). Essentially, co-design gives a voice to the community and empowers them to create something that is valuable to them (Palmer et al., 2019). Community members, key-informants and researchers work together towards a goal determined by the community (Palmer et al., 2019). In developing this project, we asked several Indigenous groups if they would be interested in culturally tailored interventions, and Inuit in Quebec expressed their desired for resilience-based interventions and tools.

Interventions and measures should be culturally sensitive

The idea of "culture as cure" is defined by increased well-being through interventions that are culturally informed and holistic (Allen, Hatala, Ijaz, Courchene, & Bushie, 2020). When it comes to culturally sensitive interventions, the options are growing but still few. A 2016 review of culturally adapted interventions for Indigenous adults found six programs had been developed in Canada (n=1) and the United States (n=5) with a sample composition of over 50% Indigenous— all of which were culturally un-adapted (Leske et al., 2016). In 2021, Graham et al (2021) identified 14 studies, which provided interventions for anxiety, depression or suicide for First Nations, Métis and Inuit. The review emerged from the need to address mental health among Indigenous, as identified by several key organizations and the Truth and Reconciliation Commission (Graham, Stelkia, Wieman, & Adams, 2021). The interventions in this review included “culturally grounded indoor and outdoor activities”, elder/peer mentorship, group activities with other Indigenous. Concluding that culture as treatment is promising for mental health, the authors called for more mental health interventions for First Nations, Métis and Inuit and for Indigenous ways of knowing to be included in further interventions (Graham et al., 2021).

Conclusions

Supported by studies that have found height stimuli subjectively and objectively arousing to most people, a height exposure paradigm responds to the need for non-trauma and lower intensity stimuli in research and clinical practice. PPG devices are one inexpensive option for psychophysiological measurement, used already in interventions targeting emotion regulation. Culturally sensitive measures and interventions are lacking, given that many have been psychometrically validated with no data on acceptability. A marriage of an emotion regulation-based approach with the technology to provide objective measurement may advance cultural sensitivity in mental health. Thus, in the body of the thesis, I describe the development, evaluation, and integration of a non-trauma psychophysiological reactivity paradigm, which aims to bypass culturally bound stimuli in using height exposure.

Additionally, I describe how we will integrate this measure into a randomized-controlled trial (RCT) co-designed and culturally adapted with Inuit in Quebec with an emotion-regulation focus. I begin with an introduction to an instrument evaluated during the reactivity testing paradigm study, the Psychophysiological Signals Portal, to facilitate biofeedback during VR-CBT trial. I then provide quantitative data on the reactivity testing paradigm. Finally, all the individual pieces of the thesis come together in Chapter 4, which describes a pilot RCT.

Chapter 1: Development and Evaluation of Psychophysiological Signals Portal

What is a Psychophysiological Signals Portal?

The National Research Council (NRC) developed the bConnected platform to manage data during remote health care encounters. For our purposes, the interface includes back-end server that will gather information from the PPG sensor during for visualization, storage, and analysis.

The evaluation of the Psychophysiological Signals Portal was conducted primarily by the first author (Q.S.) while implementing the tool in the pilot trial. Other team members, such as M.K., were involved with the implementation and evaluation of the instrument. This data is qualitative, collected in notes, correspondence between members of the research team, and observations throughout the pilot trial. Q.S. conducted thematic analyses on these notes and correspondence.

Thematic analyses for qualitative data can be methodologically rigorous when following trustworthiness criteria, such as those outlined by Nowell et al. (2017). Trustworthiness criteria can include member-checking, data collection triangulation, and rationalizing methodological, theoretical, and analytical choices. Q.S., who implemented the Portal, thematically analyzed the data, ensuring the codes' accuracy in a manner similar to member checking. I collected several types of data (triangulation), such as coded correspondence, note-taking, example data, and observations from the two members who implemented the Portal. Given the study's design, a pilot trial to evaluate the implementation of a psychophysiology Portal and paradigm, thematic analyses are appropriate. We follow Nowell et al.'s stepwise process; Q.S. reviewed the evidence, assigned initial codes, compiled themes, and then re-verified the codes.

How was the "Portal" developed?

Installation and piloting of the psychophysiological Portal occurred in late August 2020. **Table 3** summarizes each of the unique codes and broader themes extracted from the qualitative data. The table is organized from most to least commonly extracted codes. While implementing the psychophysiology Portal, issues affecting its future implementation (n=38) and technical problems (n=31) were common, while challenges surrounding data reliability (n=15) and human-generated errors (n=5) were less common.

Technical Problems

The Portal is stored on a remote server, monitored by employees of the National Research Council. Nonetheless, the server went down several times during piloting, which prevented installations and the use of the Portal. Besides creating problems for its use, the server being down also reflects a potential future issue. We hope to implement this Portal in remote and low-resourced settings. In this case, consistent monitoring of the server is necessary. Problems with the server were the most common technical problem; thus, adequate IT resources or automation of the server will be crucial. The next common issue involved problems logging in to the Portal and being logged out while using it. The team resolved the log-in issues while debugging and updating the Portal. Some other transient technical issues were resolved by uninstalling and reinstalling the Portal or disconnecting the Bluetooth dongle, which connects the PPG sensor to the Portal. We suspected Bluetooth errors several times (n=5).

Another technical issue was installation. In total, installation was a 24-step process involving: disabling firewalls, installing and initializing docker, WSL (linux compatibility) installation, data backup, installing the Portal front and back-end, and saving program files. As such, the installation is a complex and somewhat error-prone task without appropriate levels of training.

Count	Themes			
	technical problems	**human error**	**future implementation issues**	**data reliability**
4	• problems with the server		• problems adding patients/sessions •problems with the server	
3			•new versions to install/having to re-install for technical issues	
2	• problems with log-in and log-out • problems accessing front-end • problems with the TPS program • lag between sensor and display • flat lining	• errors during installing	• need ability to extract data • lag between sensor and display	• information on algorithms is difficult to find or proprietary • flat lining • lag between sensor and display
1	• problem with firewall/anti-virus software • ability to see more than one past session •ability to pause the session • issues with sensor units • problems with page refresh	• issues with Bluetooth	• program does not install across multiple accounts on each device • the program does not start automatically • problems with display/graphing • battery level does not display • certain proprietary metrics not available • graphics capability limited • ability to pause recordings • no event markers • cleaning the sensor without degrading it • having IT staff onsite • ability to see more than one past session • organization of pages (chronological order)	• repeating values within the data • no event markers • ability to troubleshoot/verify data • issues with sensor units

Table 3: Themes extracted from qualitative evaluation of Portal

Human Error

The research team purchased a vetted Bluetooth dongle for the desktop computer in the laboratory to ensure a stable connection. We mistakenly used the in-built Bluetooth capacities of the research laptop, which may have interfered with the sensor device and caused flatlining. Thus, installation and use of a psychophysiology Portal at this level of development require a moderate level of computers and programming.

The implementation of the Portal was an evaluative process, and some of our observations led to changes or new versions of the Portal to resolve technical difficulties (e.g., the ability to see more than one past session in the patient's online "folder"). Others are still to be resolved by our research group or equipment manufacturers (e.g., potential issues with sensor units, problems with page refresh, and the ability to pause visualization sessions).

Future Implementation Issues

One of the most commonly extracted codes was problems when we attempted to add "patients" (see **Figure 1**) and create sessions (see **Figure 2**). The research team would try to add dummy data (as the Portal is still in its piloting stage) to create patient profiles or create a session to record the psychophysiological data (*Chapter 2*). Nonetheless, the Portal would often display errors "patient not created" or "session not created"; sometimes before sessions with participants and slowing the testing progress. Before starting sessions with a "patient," the user has 19 fields to fill.

In piloting these features, the create patient and create session functions lacked both clinical utility and feasibility. A given name, family name, unique email, date of birth, and gender are required fields. The Portal is on a secure server, where only local downloads are possible; nevertheless, users may not want or need to provide all the information requested for many reasons. Sometimes the gender of the patient is not shared with the clinician, for example. Equally, the session creating feature has far too many options and unnecessary fields, where ease and brevity might be preferred. During therapy sessions, details of the type and length of exposures may change. It might be more beneficial to click a button to start the patient session and have scheduling and session notes features separately.

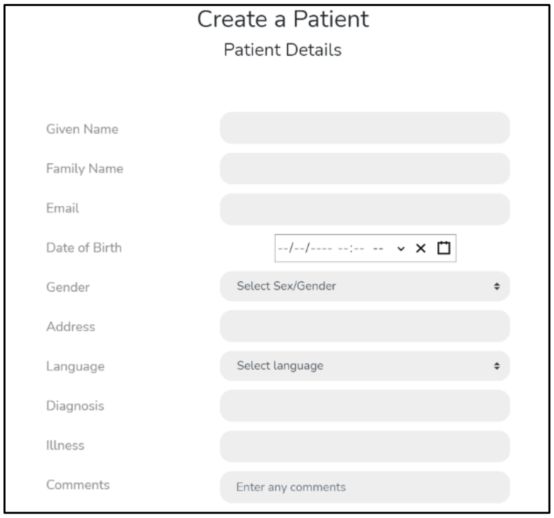

Figure 1: Create patients

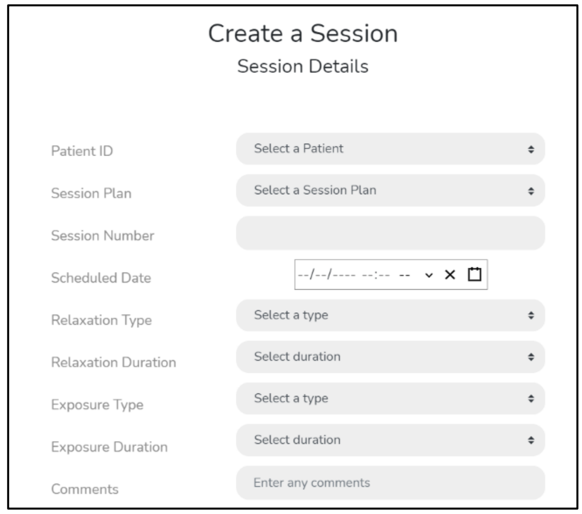

Figure 2: Create sessions

Some other possible barriers to the Portal's future use are the installation process; besides being an error-prone process, users may probably be specialized in other areas and not have sufficient technical knowledge to do installations or troubleshoot problems occurring with new versions software. Moreover, the Portal installs on one account only per computer, even if the initial download is performed on the administrator account. Thus, future developers should be put into a compact, downloadable file, or else technicians should be onsite for the installations for each user.

The ability to extract data, display battery levels, pause recordings mid-session without lagging visualizations, create event markers, and see on the Portal the data from several past sessions should all be integrated into the tool, making it clinically a useful Portal. In this way, clinicians could pair their sensors with the Portal, knowing they will be reliable throughout the session, and mark or pause the session when something of interest occurs (e.g., sensor slipping, a new segment begins). For the organization of patient data, the main pages should display scheduled sessions from the nearest date to the farthest date or have a feature to organize the page as the clinician desires.

Equally, tracking psychophysiology across sessions by viewing all past sessions will be helpful; this could be done by not only seeing each session summary (see **Figure 3**), but a summary of all sessions with some way interprets each. Because many algorithms are proprietary, extracting them for use or having more information on the algorithm is not always possible. However, our research team developed a python script which filters heart rate and skin conductance threshold values. The script equally averages the data, sampled every second, over 5 seconds, and outputs more interpretable graphical displays. Its last feature is calculating mean (standard deviation) and median for each data segment (see **Appendix 1** of *Chapter 2)*. Future work could expand the Portal using these codes and an event marker function, automatically calculating average values per segment, and displaying this on a progress summary page. For example, the Portal could look more like **Figure 4**.

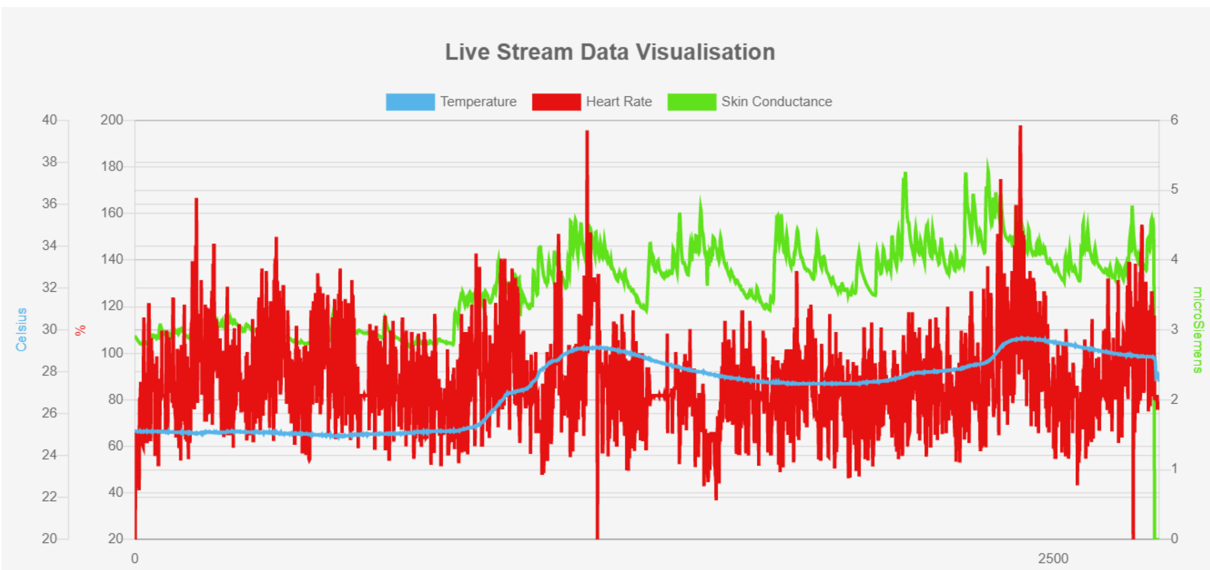

Figure 3: Example Display of data in Portal

Before we can use the Portal in other settings, we will have to consider a few issues. There is a slight lag between the sensor input and Portal display output; though potentially unavoidable, the lag should be reduced as much as possible and eliminated from certain processes entirely, such as when the session is "paused." Additionally, implementation in future settings might consider ways to clean the sensor without degrading it, such as ultraviolet light treatments. Certain resources will be required, such as at least two computers and a technician nearby, onsite, or able to make changes/installations remotely.

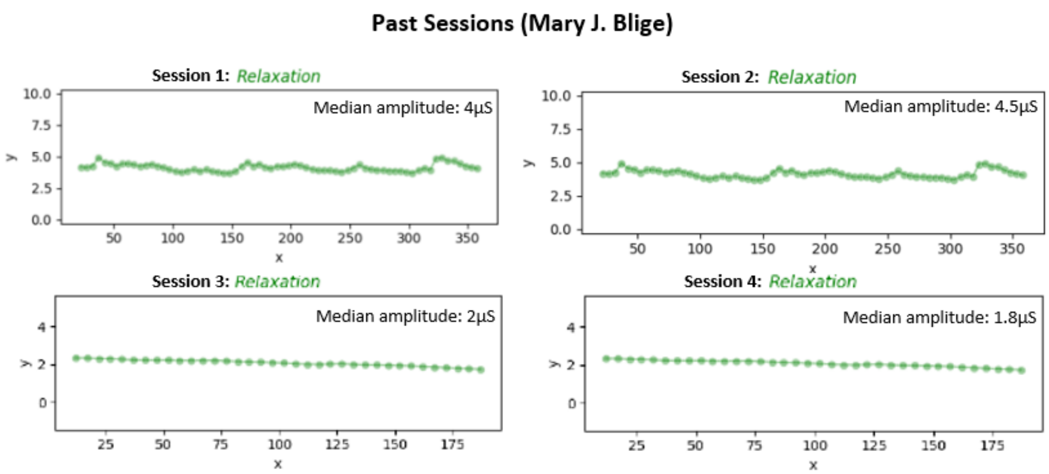

Figure 4: Example of appearance of psychophysiological portal with future implementation optimizations (dummy data). Signals are more interpretable, being averaged and filtered for artifacts. Side-by-side windows allow for easy comparison of past sessions. Summary stats provided for interpretation and tracking. Title of plots, such as "Relaxation", could be plotted using event markers during testing session.

Data Reliability

Issues with data reliability were less common and mostly related to human errors or lack of information about psychophysiological metrics and algorithms. For example, we observed exact values that seemed to repeat in the data set or flat-lined values during some test sessions. However, since the implementation was prone to error and there was sometimes little information available about the sensor, we had to troubleshoot by pairing the PPG sensor with other available visualization programs.

What are the next steps?

The development and evaluation of the Portal involved the collection of psychophysiological data. This data advances the second aim of this thesis: to test a non-trauma height exposure reactivity paradigm for use with the Portal and during later steps of the project.

Chapter 2: An Objective Non-Trauma Psychophysiological Reactivity Testing Paradigm: Pilot Study

Short Title: Psychophysiological Reactivity Testing Paradigm

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Impact Statement

We developed a psychophysiological reactivity paradigm using two virtual reality environments, a forest walk and height exposure. Among healthy controls, the level of subjective arousal and skin conductance response during the height exposure demonstrated that the paradigm evoked emotional arousal. We propose that this paradigm could extend to settings where non-trauma exposure paradigms are needed, such as in populations where exaggerated reactivity is related to problems with emotion regulation.

Abstract

Problem: When an individual experiences difficulty in emotion regulation, psychophysiological reactivity is also dysregulated. Exposure to heights is naturally arousing, even among people without a fear of heights. Thus, heights could be a clinically useful exposure cue, especially when trauma cues would not be appropriate. **Methods:** In this paper, we pilot a psychophysiological reactivity testing paradigm among healthy participants using a forest walk and height exposure in virtual reality (VR). A portable finger photoplethysmography (PPG) device recorded heart rate and skin conductance response (SCR)for approximately 40-minutes. Participants also completed Visual Analogue Scales for anxiety, emotional arousal, and emotional valence following each segment of the paradigm. **Results:** The median age of the n=16 participants included in our analyses was 22 years (n=8 females). Overall, the participants reported few difficulties in emotion regulation (median DERS-16 score 26). We observed a peak in SCR during the height exposure segment. In non-parametric tests, reactivity to height was significantly different from the baselines and the forest environment. Subjective anxiety, arousal, and (negative) valence increased during the height exposure compared to other segments. The forest environment had minimal effects on SCR and subjective affect. Heart rate did not seem to be affected by height exposure. **Conclusions:** Height exposure can evoke both subjective and objective arousal in healthy participants, proving the feasibility of heights as an exposure cue. The paradigm necessitates further testing among a population with more variation in psychopathology

Introduction

Emotion dysregulation manifests both in self-reported symptoms and in psychophysiological reactivity. Heart rate variability and electrodermal reactivity are typically higher; however, when emotion regulation improves, reactivity also regulates. (Azbel-Jackson, Butler, Ellis, & van Reekum, 2016; Berna et al., 2014; Gratz et al., 2015; Kraiss et al., 2020; Shaffer & Ginsberg, 2017a; Shepherd & Wild, 2014; Stone, Lewis, & Bylsma, 2020; Yang et al., 2021). Currently, measuring psychophysiological reactivity is done with stimuli that are too intense (Bernardo et al., 2020), such as trauma cues or social stress (Berger et al., 2017; Hermosura, Haynes, & Kaholokula, 2018; John-Henderson, Gruman, Counts, & Ginty, 2020; Kaholokula, Grandinetti, Keller, Nacapoy, & Mau, 2012; Yang et al., 2021). Evoking trauma responses may not be safe or appropriate for everyone, especially among marginalized groups (Edward, Christina, Jameson, & Elizabeth, 2018). Additionally, for participant retention across longitudinal studies trauma exposure is not an optimal stimulus, as attrition when using trauma cues is around 16% (Benbow & Anderson, 2019). This attrition is sometimes because participants fear the exposure stimulus too much to return to treatment (Benbow & Anderson, 2019).

Finding less intense stimuli will help phenotyping reactivity associated with emotion dysregulation while increasing acceptability and cultural sensitivity. For one, psychophysiology can be tracked in real-time and demonstrate treatment outcomes (Yang et al., 2021). For two, psychophysiological metrics can serve as a treatment modality, involving feeding back signals to the patient (e.g., biofeedback) or in ecological momentary assessment (D. Colombo et al., 2020; Joseph, Jiang, & Zilioli, 2021; Raugh, Chapman, Bartolomeo, Gonzalez, & Strauss, 2019; Schuler et al., 2021; Targum, Sauder, Evans, Saber, & Harvey, 2021; Van Doren et al., 2021). Finally, some stimuli, which evoke innate responses, can generalize across the general population. These stimuli have evolutionary importance and, with a certain degree of conditioning, evoke arousal and even fear in individuals (Arakawa, Fukumoto, & Tsuji, 2008; Liu, Lin, & Wang, 2021; Ren & Tao, 2020).

Thus, we might ask whether safe experimental paradigms not using trauma cues would be needed to observe objective outcomes of interventions. There are clear challenges to relying on subjective measures only; we require retrospective reports where respondents must align their experience with the worldview contained in the questions. Moreover, the reliability of responses to psychometric scales and the cultural safety can be questionable in several populations (Foronda, 2008; Gomez Cardona et al., 2021). However, exposure to heights is a stimulus that causes arousal in those who fear heights (e.g., acrophobia) and controls (Diemer et al., 2016; Peterson, Furuichi, & Ferris, 2018). Moreover, for some, exposure to heights is subjectively not too intense and in most people would not evoke a trauma response (Diemer et al., 2016). Heights are equally a stimulus that is considered innately arousing by some researchers and theorists (Arakawa et al., 2008; Liu et al., 2021; Ren & Tao, 2020).

Based on the potential universality of the height stimulus, our group developed a virtual reality exposure paradigm. We aim to establish psychophysiological responses at rest and during stress (e.g., height exposure) using the paradigm. In this study, we describe initial findings from a stress reactivity exposure paradigm among participants from the general population to pilot the feasibility and usefulness. However, eventually the paradigm could measure objective acute stress for remote and culturally sensitive treatments for all.

Hypotheses

Based on the literature in this area, we expected participants to report both subjective and psychophysiological arousal to a VR height exposure.

Methods

Sampling

We recruited individuals from the healthy general population (n=20) between the ages of 14-60 for this study. Inclusion criteria were to identify as generally healthy and be between the ages of 14-60. In addition, we excluded at-risk individuals, such as those with epilepsy or heart conditions. The participants provided no information about race or ethnicity, but gave information about maternal languages.

Materials

ThoughtTechnology eVu TPS

The eVu TPS is an FDA and Health Canada cleared photoplethysmography device developed by ThoughtTechnology. Acting as a finger sensor with two skin electrode pads, the eVu TPS transmits wirelessly via Bluetooth. ThoughtTechnology can access heart rate (in beats per minute) and skin conductance (in microSiemens) with their algorithms. Given that the eVu TPS is light, portable and wireless, it fit well with the study's needs, such as unencumbered movement and potential for remote use. The eVu TPS is compatible with our VR exposure experimental design (e.g., portable, medical-grade).

Virtual Reality Environments

Forest Walk

The first virtual environment that participants viewed was a forest walk for 5.5 minutes, which we intended as a relaxing stimulus (in figures referred to as "relaxation" segment). Participants were instructed to walk and explore the environment, being mindful to keep their hands at their sides, not to cause motion artifacts in the psychophysiological readings. Research assistants were present during the duration of the reactivity testing paradigm, but we warned the participants to keep interaction minimal to increase immersion in the VR. The forest environment displays grasses and forest cover and trees and a water source far in the distance. Participants could also see a caribou at a distance, up a hill from where the participant stands. In addition, the VR environment played bird sounds, rustling and distant water in the background.

Height Exposure

In the height exposure, participants experience an urban construction site of a skyscraper building. A plank connects two service elevators on the distant ends of a level of the skyscraper, and participants can view the street several virtual "floors" below them and hear the sounds of traffic. The participants were kept their hands to their sides and interactions to a minimum during the 5.5 minutes. They walked across the plank for the duration; however, if they could not cross the plank even once or their distress was too intense, the minimum exposure time was 2 minutes. (All participants completed the entire 5.5 minutes).

Measures

Psychometric measures

To measure five domains of emotion regulation ability, participants completed the 16-item version of the Difficulties in Emotion Regulation Scale (DERS-16) (Bjureberg et al., 2016; K. Gratz & L. Roemer, 2004). The DERS scales are reliable, with an internal consistency ranging a= .69-.97 and test-retest of rrb=.88; ρI=.85 (Bardeen, Fergus, Hannan, & Orcutt, 2016; Bjureberg et al., 2016; K. L. Gratz & L. Roemer, 2004; Ritschel, Tone, Schoemann, & Lim, 2015; Victor & Klonsky, 2016). The scale seems consistent across groups with different demographics and is even adapted for certain cultures—though no studies yet in Indigenous groups (Giromini, Velotti, de Campora, Bonalume, & Cesare Zavattini, 2012; Ritschel et al., 2015). A French version of the DERS is validated (Dan-Glauser & Scherer, 2013).

We also assessed participants' ratings on the post-traumatic stress disorder (PTSD) using a five-item scale, the Primary Care PTSD Screen for DSM-5 (PC-PTSD-5), that uses the four symptom cluster criteria of the Diagnostic and Statistical Manual 5 (Prins et al., 2016). The PC-PTSD-5 is reliable *(test-retest rrb*=.83) (Prins et al., 2016) with a cut-off of 3. A French translation of the scale is available through the Clinical Psychology and Psychotherapy Unit of the Bielefeld University.

The Generalized Anxiety Disorder 7-item (GAD-7) (Spitzer, Kroenke, Williams, & Löwe, 2006)is a severity measure for anxiety (Plummer, Manea, Trepel, & McMillan, 2016). We can interpret scores of 5, 10, and 15 are generally interpreted as mild, moderate, and severe anxiety. The GAD-7's favourable psychometric properties are consistent among Indigenous populations with a= .86 internal reliability (Chahar Mahali, Beshai, & Wolfe, 2020). Micoulaud-Franchi et al., (2016) provide a validated French translation (Micoulaud-Franchi et al., 2016).

The Patient Health Questionnaire 9 items (PHQ-9) is a severity scale for depression (Kroenke, Spitzer, & Williams, 2001), separating responses into mild, moderate, moderately severe and severe categories. The scale can also identify depression with a cut score of 10 (Levis et al., 2020). The PHQ-9 has favourable psychometric properties with Indigenous populations, such as a strong internal consistency a= .94 (Harry & Waring, 2019).

We included three Visual Analogue scales for Anxiety (VAS-A), emotional arousal (VAS-EA), and emotional valence (VAS-EV) (Langley & Sheppeard, 1985). The construct, convergent, and cultural validity of VAS are supported by several studies, as well as their sensitivity (Abend, Dan, Maoz, Raz, & Bar-Haim, 2014; Langley & Sheppeard, 1985; Lesage, Berjot, & Deschamps, 2012; Reips & Funke, 2008). Emotional stress-inducing paradigms in which subjects rate arousal and valence to stimuli have shown that subjective ratings correlate with physiological measures, such as skin conductance (Brouwer & Hogervorst, 2014).

Psychophysiological measures

We collected cardiac and electrodermal measures, such as heart rate (HR) and skin conductance (SC), throughout the study. The eVu TPS measures blood volume pulse (photoplethysmography) signal) at a 300 HZ sampling rate and then uses an algorithm to input heart rate (HR) in beats per minute (BPM). The eVu TPS measures skin conductance in microSiemens (µS), which includes both skin conductance level (SCL) and skin conductance response (SCR) components; however, data were filtered and averaged to extract SCR only. We removed SCL as we were interested in phasic skin conductance, which indicates reactivity.

Electrodermal activity and reactivity

Skin conductance (SC) is a form of Electrodermal activity (EDA) reflecting sympathetic nervous system arousal (Boucsein, 2012). Reviews of emotion and emotional attachment indicate that higher skin conductance response (SCR) and skin conductance level (SCL) is associated with the capacity to emotion regulate and higher anxiety (Gander & Buchheim, 2015; Kreibig, 2010). At healthy resting levels, skin conductance is <4 µS with a reactivity response of <3 µS (Seth Davin Norrholm et al., 2016; Bethany C. Wangelin & Peter W. Tuerk, 2015).

Cardiac activity and reactivity

Cardiac activity, such as HR and HRV, is supported by recent reviews for objective measurement of psychological well-being and improved emotional and physical health using biofeedback (Goessl, Curtiss, & Hofmann, 2017; Kim, Cheon, Bai, Lee, & Koo, 2018; Lehrer et al., 2020). Equally, some cardiac activity is also a risk marker for several psychological disorders, such as post-traumatic stress disorder (Ge, Yuan, Li, & Zhang, 2020; M. C. Morris, Hellman, Abelson, & Rao, 2016). Short-term HR is on average 65-66 beats per minute (BPM) (Dantas et al., 2018). For healthy individuals, cardiac activity is within healthy ranges at rest of <70 BPM (HR), >100 ms (HRV; SDNN)(Bourassa et al., 2019; Ehlers et al., 2010; Liddell et al., 2016; Loucks et al., 2019; S. D. Norrholm et al., 2016; Schubert et al., 2019; Shaffer & Ginsberg, 2017b; Tan, Dao, Farmer, Sutherland, & Gevirtz, 2011; B. C. Wangelin & P. W. Tuerk, 2015; Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009).

Procedure

This study was in accordance with The Code of Ethics of the World Medical Association's Declaration of Helsinki. Our institution's Research Ethics Board approved by our, and each participant provided written informed consent. Several segments to the Reactivity Testing Paradigm establish both rest and stress levels of heart rate, and skin conductance (see **Figure 1**). We placed an optical sensor, eVu TPS, on the participants' index finger of the non-dominant hand. Once we collected a silent, seated baseline of 3 minutes, the psychophysiological recordings were interrupted only to change VR environments or complete Visual Analog Scales. During a habituation period, the participants completed self-reports of psychological well-being, which usually took 10 minutes. Participants are immersed in a nature environment in the first VR segment, a forest where they are free to walk and explore for 5.5 minutes. A height exposure is the subsequent segment, again lasting 5.5 minutes. Each of these environments was created in inVirtuo by Dr. Bouchard. Next, a "movement baseline," where participants walked around and explored a construction site (no height exposure) for 3 minutes. We recorded for an additional 10 minutes, as participants spontaneously recovered from the physiological reactivity to the height stimulus (presenting no stimuli and leaving them time to return to normal psychophysiological levels). Together, the duration of the experiment was about 40 minutes. We used RedCap to collect and store survey data (Harris et al., 2019; Harris et al., 2009).

Analyses

Data Filtering and Artifact Removal

To accurately identify peaks and not simply gradual increases in skin conductance observed over time, we filtered SC data with a threshold value of 0.04 µS and average over 5 seconds (Farnsworth, 2019; H. F. Posada-Quintero & K. H. Chon, 2020). Since our study involves movement in a VR space in addition to exposure to a potential stress-inducing situation, we filtered the data with a the lower limit of 40 bpm and upper limit of 200 bpm (World Health Organization, 2003). Heart rate was also averaged over 5 seconds. For the python scripts for data processing see **Appendix 1**.

Data Analyses

We used R Statistical and Computing Software and Python to process and analyze our data (R Core Team, 2021), including several packages. We report descriptive statistics for several participant characteristics, including frequencies, means and medians. Subjective measures (VAS-A, VAS-EA, and VAS-EV) were tested with non-parametric repeated measures analyses (Friedman's rank-sum tests) to analyze within-person repeated measures differences. We followed this with posthoc tests, Wilcoxon signed-rank tests for multiple testing using the Bonferroni correction. For both objective and subjective data analyses, Kendall's W indicated effect size, interpreted as 0-1 (1 being perfect) (Tomczak & Tomczak, 2014). In comparing subjective and objective data, we standardized SCR using z or t score standardization, based on previous recommendations for SCR analyses (Braithwaite & Watson, 2015; Braithwaite, Watson, Jones, & Rowe, 2013). We correlated subjective and objective measures with Spearman's correlations.

Codes provided by (Huber, 2012) and (Xu, 2016) facilitated visual inspection of cleaned and filtered SCR using of locally weighted smoothing. We also modified this code was to find local maxima and latency of the peak. For within-person differences SCR (non-standardized), we used paired Wilcoxon signed-rank tests with Bonferroni correction on media scores for each segment. For objective data, we calculated effect size with rank biserial correlations (Tomczak &Tomczak, 2014). For all analyses, we accepted an alpha of $p<0.05$ significance after correction for multiple testing.

Results

Preliminary Analyses

We collected SCR, HR, and subjective measures (e.g., arousal, anxiety, valence) from n=20 participants. While we piloted and adjusted the Portal and the paradigm, n=4 participants had problems with equipment, sensor, or the length of the exposures and we excluded them from the analyses. We shortened the duration of the exposures and continued testing and analyzing the data for n=16. For psychometric scales, n= 1/592 data points (0.169%) were missing, which we extrapolated from similar items of the scale (PHQ-9). In our primary analyses (n=16), one participant had issues (extremely high values leading to flatlining) with skin conductance. This part (SC) of their data was rejected, leading to a 5% rejection rate for skin conductance data. We removed 0.55% (n=67/12000 data points) that were beyond our a priori threshold values during data filtering and artifact removal in SCR and HR. These were left as empty values that were removed points in some analyses. None of the psychometric data was multivariate normal, using Mardia’s tests for skewness and kurtosis. Several of the VAS-A/EA/EV did not meet assumptions of normality.

Participant Characteristics

The final sample included in the analyses was n=16 of participants from the healthy general population (**Table 1)**. The median age was 22.3 years and was equally composed of males/females and English/French speakers. Around 19% (n=3) met the cut-off score of 10 for generalized anxiety (GAD-7) and n=4 for depressive symptoms on the PHQ-9. Two participants screened positively on the PC-PTSD-5 (**Table 2**). However, few participants indicated having been diagnosed with a psychiatric disorder in their lifetime. Two participants reported being diagnosed with a psychiatric disorder. Overall, there were *few* difficulties with emotion regulation among this sample, with a median [range]score of 26[17, 56], where the scale has a minimum score of 16 and a maximum of 80 (**Table 2**). Items from difficulties in emotion regulation *strategies* and *goals* subscales were more commonly endorsed than *nonacceptance, impulses or clarity*: medians (min, max): 8.5[5, 18], 6[3,15], .3.5[3,10.], 3[3,15.], 3[2,6].

Objective Measures

Skin Conductance Response (SCR)

Looking at the cleaned and filtered data, we observed no linear trends in skin conductance response. Three prominent peaks were observed in skin conductance, occurring at 425 (habituation), 905 (height exposure), and 1540 seconds (recovery) (**Figure 2**). The amplitude of the peaks was 4.67, 4.79, 4.92 μSiemens. From the forest environment to the height exposure, the median skin conductance response increased (median (interquartile range): 2.89(2.14), 5.53(3.34). In paired Wilcoxon signed-rank tests with the Bonferroni correction, SCR during the height exposure was significantly different from the resting baseline (rrb= .87, p=0.002) and forest environment (rrb=.88, p=0.002) and movement baseline (rrb=0.88, p=0.002). Additionally, differences between the forest environment and the movement baseline were significant (rrb=0.88, p= 0.002), but between the resting baseline and the forest environment, nonsignificant (rrb=.46, p>0.05). When we removed participants with severe psychiatric symptoms (n=2) or past psychiatric diagnoses, there were no differences in the results.

Heart Rate (HR)

The cleaned filtered heart rate data revealed no trends but had several very small peaks. However, as seen in **Figure 3,** there did not seem to be any distinct response in heart rate during particular segments of the reactivity testing. Median HR (in BPM) was 76.1, 76.2, 77.0, 76.4, 76.6, and 74.5, during resting baseline, habituation, the forest, the height exposure, the movement baseline, and the recovery period, accordingly. We found no significant differences between height exposure or the forest environment and any other segment ($p>0.05$).

Subjective Measures

Friedman's rank-sum tests indicated that there were significant within-person differences on the VAS-A, VAS-EA, and VAS-EV with $\chi2= 23.4$ (6) $p<0.001$, $\chi2=26.0$ (6) $p<0.001$, and $\chi^2= 26.8$ (6) $p<0.001$, respectively. At the beginning of the study, most participants were slightly more anxious (p=0.04) and slightly but not significantly more aroused and excited ($p>0.05$) than they were after being able to relax and get comfortable with VR (i.e., forest environment) ($p>0.05$). Following the height exposure, participants felt more anxious (p=0.03), more felt excited (p=0.02) and less pleasant (p= 0.04) than following the relaxing forest environment. However, participants quickly felt more pleasant (similar to baseline levels) after the movement baseline (p=0.05) and in recovery (marginally significant p=0.10). In the end of the reactivity testing, participants felt more neutral (movement baseline versus recovery p= 0.001) than they did when they had a chance to recover back to levels of calm observed during other parts of the studies(p=0.03) (**Figure 4**). The magnitude of the changes as measures by Kendall's W was for the VAS-A (w=.26), VAS-EA (w=.35), VAS-EV (w=.58) (**Figure 4)**. We detected non significant associations between median z-scores (all-segments, within-person) of SCR and any VAS-A, EA, or EV at any segment.

Emotion Regulation

Non-parametric correlations between change scores (median z scores) on SCR and HR with psychometric rating scales (DERS-16, GAD-7, PHQ-9, PC-PTSD-5) were insignificant. However, change scores on the VAS-EA item (z-scores) were marginally associated with sum score on the DERS-16 (rho=0.45, p=0.08), as well as two subscales, *goals* (rho= 0.45, p=0.08) and *strategies* (rho= 0.46, p=0.07).

Discussion

SCR and subjective affect changes after height exposure

This study aimed to develop a non-trauma-cued reactivity testing paradigm using heights. We confirmed subjective increases in anxiety, emotional arousal, and changes in emotional valence (less pleasant feeling) when participants viewed heights. Additionally, the skin conductance response (SCR) during height exposure was consistent with an expected reactivity to height. We provide preliminary evidence for our hypothesis that height exposure evokes both emotional and physiological arousal in healthy participants.

SCR and subjective affect (arousal, anxiety, valence) increased from forest to height exposure, and there was a peak located at the beginning of the height exposure. These findings replicate previous studies. During image viewing tasks in another study, threatening images evoked arousal in anxious and depressed individuals and healthy controls (Rosebrock, Hoxha, Norris, Cacioppo, & Gollan, 2017). During VR height exposures, researchers have also observed similar physiological response patterns between acrophobic individuals and controls. The SCR might depend on the direction of gaze (e.g., downwards from a height or straight forward) (Diemer et al., 2016).

Meanwhile, the lack of effect observed in heart rate is consistent with previous studies reporting better specificity with skin conductance response (Yang et al., 2021). HR is involved in sympathetic and parasympathetic nervous systems, and this is why the relationship between HR and arousal is more complex than between skin conductance and arousal (Garfinkel & Critchley, 2016; Yang et al., 2021). Within individual HR seems to be reasonably stable, actually (Quer, Gouda, Galarnyk, Topol, & Steinhubl, 2020). For instance, though there might be seasonal trends and some infrequent wavering outside of norms, the resting heart rate is fairly stable longitudinally at 65 beats per minute (Quer et al., 2020).

Forest environment does not significantly change SCR or affect

We expected the forest environment to relax participants from any anxiety or emotional arousal they might feel simply from entering the study setting, being in an observed, novel environment. VR nature experiences might have similar positive effects on affect as physical outdoor environments, but reviews and meta-analyses indicate that this similarity is mostly in improvements in negative affect (Browning et al., 2020; McMahan & Estes, 2015; Reese, Stahlberg, & Menzel, 2021). VR nature environments have also shown to produce physiological recovery in heart rate and other metrics in healthy participants (Annerstedt et al., 2013; Wang, Shi, Zhang, & Chiang, 2019). However, in this cohort of healthy participants, neither SCR nor HR decreased significantly from the resting baseline to the forest environment. Most participants were not anxious or stressed coming into the study nor generally, as indicated by their overall trait anxiety scores (GAD-7). In addition, anxiety scores from VAS from baseline to forest environment were significantly different but more on the side of not anxious, potentially explaining the small changes evoked by the forest environment.

Regulation of subjective affect?

In our sample of healthy participants, the association between self-reported emotion dysregulation and reactivity was marginal. The positive associations between change in *emotional arousal* and self-reported difficulties in emotion regulation did not quite reach significance. In a larger sample, we might see stronger associations. In the case that what we have observed is a small undetected effect, it replicates previous studies where healthy controls rated threatening stimuli less arousing than anxious and depressed individuals (Diemer et al., 2016; Rosebrock et al., 2017).

Wiemer et al. (2021) recently explored the effect of reappraisal (emotion regulation strategy) on conditioned fear responses in healthy participants. Those who downregulated their emotions through reappraisal also reported reduced negative valence and arousal to negative stimuli (Wiemer, Rauner, Stegmann, & Pauli, 2021). Since our current sample had the ability to regulate their emotions well, this may have resulted in a fairly low level of anxiety and arousal; however, more work is needed to confirm.

Motion does not explain observed effects

PPG devices are susceptible to noise, especially if worn during motion. We instructed participants to limit the amount of hand and arm motion during the forest environment, height exposure and movement baseline to reduce the number of motion artifacts. Equally, based on a skin conductance response during the movement baseline, we estimated the magnitude of simple movement in a relatively neutral environment versus the effects of the forest environment and height exposure. The findings seem to support the idea of exposure to height having a unique effect on physiology, not evoked from simply moving in a neutral environment.

Strengths, limitations, and future directions

This study has several strengths. We used both objective and subjective measurements, avoiding the pitfalls of either type through cross-checking. Recent work links psychophysiological reactivity with treatment response in post-traumatic stress disorder, characterized by difficulties in emotion regulation (e.g., Yang, Mady& Linnranta, 2021). Thus, this newly tested reactivity testing paradigm has several possible clinical applications. Where disorder-specific or non-resilience-oriented approaches are contraindicated, such as among Inuit and Kanien'kehá:ka (Mohawk) (Gomez Cardona et al., 2021), a paradigm based on a fairly low-intensity and seemingly universal stimulus would be useful. Moreover, the reactivity testing paradigm could be relatively low-cost and straightforward to implement with PPG (Castaneda, Esparza, Ghamari, Soltanpur, & Nazeran, 2018). Future work should confirm the feasibility of the paradigm as a generalizable tool to use in multi-cultural settings and verify its benefits as a clinical tool.

The paradigm requires validation in a larger and more divergent sample. For instance, in some subgroups of the population heights may be less arousing or have different significance, such as in habitually-height exposure individuals (e.g., construction work). The current study sample was balanced for sex, gender, and maternal language; thus, future work could disaggregate the findings based on race, ethnicity, cultural factors, sex, or gender with a larger sample. The inclusion of other psychophysiological metrics, such as heart rate variability, may further characterize responses to the height exposure. Despite the inclusion of healthy, a small proportion of our sample reported lifetime psychiatric diagnoses or reached diagnostic cut-offs on self-reports for anxiety and depression. Self-report screening questionnaires seem to overestimate the prevalence of some disorders, including depression (Thombs, Kwakkenbos, Levis, & Benedetti, 2018). We excluded participants with prior psychiatric diagnoses made by a medical professional or greatly exceeding diagnostic cut-offs on the self-report scales. Combined with the knowledge of probable overestimation by rating scales, we likely addressed this concern in conducting analyses with these participants removed.

Conclusion

We present preliminary validation of a height exposure paradigm to replace trauma-cued exposure. The psychophysiological reactivity testing paradigm necessitates further validation in more extensive and more divergent samples, including specific ethnic populations such as Inuit that have been object of chronic traumatic experiences. The paradigm could provide an approach to more culturally appropriate and objective outcome measurement for both clinical treatment and trials if successfully validated.

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Authors Notes

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Chapter 3: Additional findings

Initial responses to the reactivity testing paradigm with Inuit

Since the reactivity testing paradigm seems feasible and useful, it could extend to more vulnerable populations. Our continuing work includes collecting initial observations of the reactivity testing paradigm among Inuit. So far, our observations (n-=3) have been consistent with expectations of height evoking physiological arousal in the literature and our sample of n=16 healthy non-Inuit participants (see **Figure 5**). As seen below, skin conductance response rose during the height exposure, and SCR was similar between the resting baseline and the forest environment.

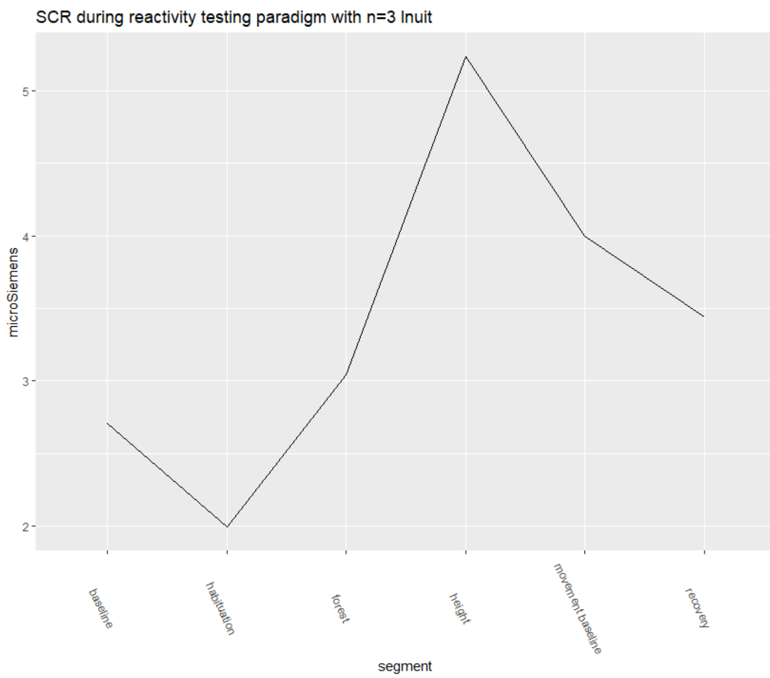

Figure 5: Initial SCR results with Inuit participants

There is yet to be any work including subjective and objective mental health measures with Indigenous populations. To decrease the ethnocultural divide in measurement, we must have tools appropriate for use in specific populations, and tools that could generalize. We assumed no real cultural significance of the heights stimulus for Inuit and non-Inuit in Quebec in our development of the reactivity testing paradigm. Future work will better confirm this hypothesis, but preliminary data suggests similar responses between healthy Inuit and healthy non-Inuit participants (**Figure 5**).

Psychophysiological reactivity can indicate treatment response (Yang et al., 2021); thus, the reactivity testing paradigm could be functional as an outcome measure. Chapter 4 describes the protocol of a culturally adapted Virtual Reality Cognitive Behavioural Therapy (VR-CBT). The trial will more robustly apply the paradigm of Chapter 2 in a clinical setting (as an outcome measure).

Chapter 4: Virtual Reality Cognitive-Behavioural Therapy (VR-CBT) tailored to Inuit in Quebec: Protocol for a Randomized Controlled Trial comparing VR-CBT and VR self-management

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Abstract

Background: Emotion regulation is a transdiagnostic process related to psychological resilience, well-being and the maintenance of several psychiatric disorders. Many psychotherapies effectively target and strengthen emotion regulation, such as virtual reality cognitive behavioural therapy (VR-CBT). We will test a novel VR-CBT to address the concerns of Inuit in Quebec, responding to the lack of culturally appropriate interventions.

Methods: We describe the protocol of a pilot two-arm randomized controlled trial with n=40 Inuit. In a ten-week VR intervention, Inuit aged 14-60 will receive Calm Place (a self-guided VR relaxation program) or a culturally adapted VR-CBT developed by our research team. The trial will assess psychological well-being with objective and subjective measures at baselines, during the treatment period and at a 3-month follow-up. The primary outcome measures are Difficulties in Emotion Regulation (DERS-16) and psychophysiological reactivity to a non-trauma-cued exposure.

Discussion: The proposed study responds to dual needs: community needs for accessible and appropriate resources for psychological resilience and well-being, and the need for randomized controlled trial evidence of culturally adapted psychotherapies. For urban Inuit, this includes creating culturally sensitive spaces, and for Inuit in Nunavik, remote treatment will be possible in the future.

Keywords

Indigenous health

Randomized Controlled trial

Emotion regulation

Virtual reality

Cognitive behavioural therapy

Co-design

Background

Emotion regulation is a set of skills and competencies that transcends diagnostic boundaries, being implicated in various psychological complaints and disorders (Cludius et al., 2020). Psychotherapy exerts a small to large effect in decreasing dysregulation and increasing the ability to regulate emotions (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Lee et al., 2020; Moltrecht, Deighton, Patalay, & Edbrooke-Childs, 2021; Sakiris & Berle, 2019). Improvements in emotion regulation during psychotherapy are also associated with decreases in anxiety, depression, substance use and other psychopathology (Sloan et al., 2017). Moreover, emotion regulation is robustly and longitudinally associated with psychological resilience (Polizzi & Lynn, 2021) and associated with life satisfaction, positive affect, and other well-being indicators with an up to moderate effect size (Kraiss et al., 2020).

Virtual reality (VR) is an interactive, three-dimensional world of images, videos and sounds. VR-assisted interventions effectively increase mental well-being, such as building the ability to regulate emotions (Desirée Colombo et al., 2019; Montana et al., 2020; Pallavicini & Bouchard, 2019). One example of VR-assisted psychotherapy is virtual reality cognitive behavioural therapy (VR-CBT), and it combines a proven effective treatment, CBT, with the technological advantages of VR. VR-CBT offers enhanced skill-building opportunities; therapists can expose clients to various scenarios with the ability to control the elements of the environment and personal needs and reactions of the client. For instance, the intensity of the exposure can be modified and objectively tracked through biofeedback (Ter Harmsel et al., 2021).

VR-CBT presents a unique opportunity for the advancement of cultural sensitivity in measurement and treatment for all. Inuit in Nunavik, the northern part of Quebec, often experience inconvenience and financial/emotional devastation when attempting to seek care for a health concern, as they may have to travel away from family to the southern part of the province (*Parnasimautik Consultation Report*, 2014). Though up to sixty percent of Inuit live in urban centers, many experience adversity in health (Marika Morris, 2016). Inuit in Ottawa reported only *fair* or *poor* access to health care (Smylie, Firestone, Spiller, & Tungasuvvingat, 2018), and in Montreal, Indigenous peoples reported trauma, anxiety and depression to be some of their primary concerns (*Montreal urban aboriginal health needs assessment*, 2012). Because of its relatively low costs, flexibility and immersion, VR has been used Indigenous contexts, such as art, storytelling, culture, language, and heritage (Dawson, 2016; Hobson, Caffery, Neuhaus, & Langbecker, 2019; Wallis & Ross, 2021; Winter & Boudreau, 2018). There is interest in digital technology for Indigenous health and mental well-being; however, most studies of telemedicine format of conventional psychotherapy (Hensel, Ellard, Koltek, Wilson, & Sareen, 2019; Hobson et al., 2019).

To expand access to mental well-being resources to Inuit in Quebec, we will evaluate the efficacy of two emotion-regulation-based VR interventions in a pilot randomized controlled trial. One of the VR interventions, a VR-CBT, was developed and culturally adapted by our research group. Our team developed the therapy with experts in VR-CBT and also experts in Inuit health and culture, an Inuit advisory committee. The other program, Calm Place was developed by Mimerse and involves guided relaxation and meditation techniques. The application is currently used in hospital settings and is rooted in nature's effects on well-being (Lindner, Miloff, Hamilton, & Carlbring, 2019). We work in a novel area in the literature, providing a VR intervention for an Indigenous population with a specific therapeutic aim (Hensel et al., 2019). Additionally, we use both objective and subjective outcome measures, a novel but robust approach (Yang et al., 2021). For example, metrics like heart rate variability, skin conductance, and diastolic blood pressure response are phenotypical in populations with difficulties in emotion regulation (Yang et al., 2021).

Research Aims

To investigate the VR-CBT's efficacy, we measure between the group and within-person improvements in emotion regulation (at post-test and follow-up) compared to active control. We also observe the interventions' effects on mental well-being: PTSD, anxiety, mood, distress, and quality of life. Lastly, we assess psychophysiological measures as objective outcomes of the interventions.

Hypotheses

Therapy efficacy

We hypothesize that VR-CBT will better decrease Difficulties in Emotion Regulation and increase other indicators of mental well-being, such as anxiety (GAD-7), depression (PHQ-9), and PTSD symptoms (PC-PTSD-5) than Calm Place. Additionally, the VR-CBT group should have normalized resting psychophysiology, decreased resting HR, SBP and DBP, increased HRV at post-intervention, lower reactivity, and recovery post-intervention. We define a therapeutic response as follows: 1) decrease in DERS-16 scores from post-treatment; 2) decrease of positively marked items or loss of positive screen on the PC-PTSD-5.

Methods

Design

The study design is a two-arm randomized controlled trial (RCT) co-designed with an Inuit advisory committee (described further in Gomez Cardona et al., *in preparation*). The RCT explores the efficacy and feasibility of a culturally adapted virtual reality cognitive behavioural therapy (VR-CBT) in comparing it to Calm Place. The first treatment arm receives a 10-week VR-CBT, while a minimal attention control self-guides for ten weeks with Calm Place.

Participants

Sampling

Self-identifying Inuit of ages 14-60 are eligible for our study. They must also fulfill several other sampling, safety, and other criteria for optimal VR and psychophysiological equipment use to be included in the study. Participants must understand their role in the trial and what their participation entails. For this reason, all participants must have a functional knowledge of either English or French. Tolerating the VR helmet, sensors and environments is an additional inclusion criterion. We exclude any individuals with current psychosis, substance abuse, or any other mental or physical condition that might preclude them from the trial (i.e., pre-existing heart conditions, epilepsy, acute mental health risk). Meeting diagnostic criteria for any specific disorder was not part of our inclusion and exclusion, given our focus on cultural sensitivity and our chosen skills-building approach. For a complete list of inclusion and exclusion criteria, see **Table 1**.

Recruitment

The research team includes an Inuit community liaison, who onsite at a local Native Friendship Centre will recruit participants for the first two arms of the trial. Word of mouth, flyers and posts on social media are all recruitment methods. Contacts with potential participants at this phase involve informing them about the study and screening for initial eligibility criteria (e.g., age 14-60, no acute medical or psychological risks).

Randomization and masking

After giving their informed consent, a research assistant will use a computerized randomization generator to randomly assign participants in a simple 1:1 ratio (VR-CBT or Calm Place). The treatment cannot be provided blinded to content. Since the measurements are self-reports and objective measurements, we do not use blinded outcome evaluation.

Sample size

There is, to our knowledge, no estimate of the effect size of emotion-regulation-based VR interventions. VR intervention for anxiety disorders had an estimated effect size of g= .78 (medium) for minimal attention controls and g=.90 (large) for no-treatment controls (Carl et al., 2019; Cohen, 1988). To attain statistical power above 90% with an alpha of p<0.5, the sample size is n= 40 is sufficient for generalized linear models with a similar effect size (power: .97, df=38, p=.05)

Procedure

10-week Virtual Reality Interventions

Culturally adapted VR-CBT

The culturally adapted therapy is a manualized CBT with an emotion regulation focus. The main therapeutic strategies are stress inoculation and guided mastery with biofeedback components. Our group is developing two VR environments, one meant for safe practice and the other for challenging emotion regulation skills. The first, called the Snowy Place, is a snowy tundra mimicking the arctic life well known to Inuit. In developing the Snowy Place, the Inuit advisory committee believed this would be a comforting environment.

The second is a small environment with many people and children, where social and other situations demand emotion regulation skills. VR environments The therapy also includes some “homework” components. For a detailed overview of the CBT manual, including a session-by-session overview, see **Appendix 1**.

Calm Place

During VR immersion, the Calm Place user may see a local with flowing water, mountains, and tree cover; a tropical atoll with sand, palm trees, and the ocean; or an arctic scene with large pines, snow cover and large stones. Each environment provides relaxing and interactive functions, such as visual breathing aids, time and weather cycles, and meditation voice-overs. The feasibility and initial user experiences have been evaluated (Fagernäs et al., 2021; Lindner et al., 2019). The research team will contact these participants weekly to remind them to use the application, verify their safety and continuity, and receive secure invitations to questionnaires via email.

Translation

A professional translator translated each of the self-reported measures that did not have existing French versions. Similarly, each measure was translated to Inuktitut.

Data collection

A protocol is in the process of approval at the Research Ethics Board and complies with the standards of the World Health Organization’s Helsinki Declaration 1975, revised 2013. Before their participation, we will fully inform everyone about their role in the study and sign an informed consent form (study procedures in **Figure 1**). Initial visits will involve checking eligibility and preference for treatment. We then randomly assign participants to one of two VR interventions: Calm Place or VR-CBT for a maximum of 10 weeks.

At the first evaluation done one to four days pre-intervention, we evaluate baseline subjective and objective measurements. We will collect participants’ rest and stress psychophysiology during an approximately 1-hour reactivity testing paradigm, where VR exposures will evoke stress (height exposure) or relaxation (nature exposure). For a description of the reactivity testing paradigm see the methods of (*Seon et al., to be submitted* in Chapter 2). Baseline measures including the Difficulties in Emotion Regulation Scale-

16, Clinical Outcome Routine Evaluation-Outcome Measure/10-item version, Warwick Edinburg Mental Well-being Scale, Generalized Anxiety Disorder 7-item, Primary Care Screen for-Posttraumatic Stress Disorder-for DSM-V, Patient Health Questionnaire 9-item, Visual Analogue scales for anxiety, emotional arousal, and emotional valence, Drug Abuse Screening Test 10-item, Alcohol Use Disorders Identification Test version C, and Severity of Dependence Scale for Cannabis. We will measure blood pressure using a calibrated device located at our University Institute as part of the procedure.

During the intervention period, we will send participants biweekly questionnaires. In their final visit, participants will repeat the procedures from the initial visit(s). Twelve weeks after their final visit, we will follow up with participants on all baseline questionnaires. Participants will also receive a small financial compensation for each visit, with a bonus compensation (gift card) for completion of a minimum of seven sessions of either Calm Place or VR-CBT

Materials

Oculus Rift S

The Oculus Rift S is a head-mounted display (HMD) using virtual reality technology. It was first released in March 2019 and is among the latest developments of its creators Oculus VR. For this study, the Rift S was connected via a 5-meter-long cable to a PC with a 64bit Intel processor and NVIDIA (spec) graphics. Its LCD is fast-switching LCD panel (refresh rate of 80 hertz) has 2560 by 1440 resolution. The Rift S controllers have 6 Degrees of Freedom (DOF), which facilitates having virtual hands (i.e., positional tracking and orientation), and the Rift has built-in audio in the head strap. While using virtual reality, Oculus VR recommends a free space of 9 by 9 feet free of obstruction for at least 6.5 by 6.5 feet. We will ensure safety by the guardian function, creating virtual barriers outside of the predefined safe space. We will use the Rift S onsite for therapy session and collecting psychophysiological data.

Oculus Quest

A later (2020) release of Oculus VR, the Oculus Quest is a Stand-alone HMD with Qualcomm® Snapdragon 835 processor. The HMD panel comprises of dual organic LEDs with 1600 by 1440 resolution and 60-72 hertz refresh rate. The Quest also has integrated audio, 6DOF, and 4GB of memory. While using virtual reality Oculus VR recommends a free space of 9 by 9 feet free of obstruction for at least 6.5 by 6.5 feet; the available space varies the guardian function ensured their safety. Participants assigned to the Calm Place arm will use this wireless headset in their homes.

Measures

Primary Outcome Measures

Difficulties in Emotion Regulation Scale-16

The Difficulties in Emotion Regulation Scale 16-item (DERS-16) is a short, valid measure of emotion regulation (Bjureberg et al., 2016; K. Gratz & L. Roemer, 2004). The scale measures one's ability to accept and be aware of their emotions, direct towards their goals, control their impulses, access regulation strategies, and have emotional clarity (Benfer, Bardeen, Fergus, & Rogers, 2019). The DERS psychometric properties are favourable, having both moderate to very strong internal consistency (a= .69-.97) and strong retest reliability (r=.88; ρI=.85) (Bardeen et al., 2016; Bjureberg et al., 2016; K. L. Gratz & L. Roemer, 2004; Ritschel et al., 2015; Victor & Klonsky, 2016). Correlating with anxiety, depression, stress, borderline traits, and emotion constructs, the DERS-16 has good construct validity (Bjureberg et al., 2016; Kaufman et al., 2016) (Bardeen et al., 2016). While consistent across demographics and culturally adapted for some groups, the scale is not yet adapted for any Indigenous groups (Giromini et al., 2012; Ritschel et al., 2015). The full DERS is translated and validated (Dan-Glauser & Scherer, 2013). Though there are no formal cut-scores for the DERS, the scale achieves moderate diagnostic accuracy (AUC) among emotional disorders, non-suicidal self-injury various populations (Hallion, Steinman, Tolin, & Diefenbach, 2018; Hatkevich, Penner, & Sharp, 2019; Perez, Venta, Garnaat, & Sharp, 2012).

Objective measures

During the initial visit and the last visit after the end of the VR intervention (minimum of seven and maximum of ten weeks), the participants undergo a psychophysiological reactivity testing paradigm. We will collect and measure several metrics, as seen in **Table 2**.

Secondary Outcome Measures

Primary Care Screen for Post-Traumatic Stress Disorder DSM-5

On a scale of 5 items, the Primary Care PTSD Screen for DSM-5 (PC-PTSD-5) first verifies trauma exposure and then evaluates the presence of the four symptom clusters of post-traumatic stress disorder (Prins et al., 2016). The five items include symptoms such as arousal, re-experiencing, avoidance, and negative cognitions/ mood. The scale has strong test-retest reliability (*r*=.83) and associates with important clinical variables like suicide (Cooper, Szymanski, Bohnert, Sripada, & McCarthy, 2020; Prins et al., 2016). With a cut score of 3, the PC-PTSD-5 has very strong diagnostic accuracy (AUC= .941) (Prins et al., 2016). The scale was translated by Clinical Psychology and Psychotherapy Unit of the Bielefeld University into French.

Generalized Anxiety Disorder Scale-7

The Generalized Anxiety Disorder 7-item (GAD-7) (Spitzer et al., 2006)is a validated self-report scale measuring anxiety presence and severity (Plummer et al., 2016). Among outpatients with anxiety and mood disorders, the GAD-7 is a reliable (p=.85) and sensitive (79.5%) measure with a cut score of 10 (Rutter & Brown, 2017). Results of the GAD-7 are mild, moderate, and severe anxiety with cut-offs of 5, 10 and 15. Among Indigenous students in Canada, the GAD-7 achieves a= .86 internal consistency and correlated strongly with related constructs (Chahar Mahali et al., 2020). The scale was translated and validated in French (Micoulaud-Franchi et al., 2016).

Patient Health Questionnaire - 9

The Patient Health Questionnaire 9 items (PHQ-9) is a depression severity measure based on the Diagnostic and Statistical Manual IV(Kroenke et al., 2001). In a meta-analysis of the scale's psychometric properties, the PHQ-9 achieves optimal sensitivity and specificity with a cut score of 10 (Levis et al., 2020). The PHQ-9 classifies respondents' depression severity as mild, moderate, moderately severe, and severe depression. Among Indigenous North Americans, the scale's psychometric properties are favourable with an internal consistency a= .94 (Harry & Waring, 2019)

Clinical Outcomes in Routine Evaluation Outcome Measure and 10 item

The Clinical Outcomes in Routine Evaluation-Outcome Measure has both 34 (CORE-OM) and 10-

item versions (CORE-10) (Barkham et al., 2013; J. M.-C. Evans, Frank Margison, Michael Barkham, Kerry Audin, Janice Connell, Graeme McGrath, Chris, 2000). The CORE-OM and CORE-10 are screening measures for psychological distress, including items for well-being, psychological symptoms, functioning, and risk. The CORE-OM has excellent internal consistency in clinical samples (a= .94) and for each of its subscales (a=.75-.94), and good test-retest reliability (p=.83) (C. Evans et al., 2002). A score of 10 differentiates clinical from general populations (Connell et al., 2007). Whereas the CORE-10 as a cut-score of 11 differentiated between clinical and non-clinical general samples with .85 sensitivity. Its internal consistency was a= .90, and it had a reliable change index of 6 points (Barkham et al., 2013). The scales' French versions were made available through the translation of the University of Toulouse, with psychometric evaluation to come in 2020-2021.

Warwick-Edinburg Mental Well-being Scale

The Warwick-Edinburg Mental Well-being Scale (WEMWBS) with both its 14 and short 7-item (SWEMWBS) versions, measures wholistic aspects of well-being. The dimensions include eudemonic, hedonic, psychological functioning, and subjective well-being (Stewart-Brown et al., 2009; Tennant et al., 2007). This scale disrupts the notion of mental illness being the opposite of well-being and has favourable psychometric properties. Using the WEMWBS, we can calculate mental health costs and quality-adjusted life-years (QALYs) (Fujiwara, Keohane, Clayton, & Hotopp, 2017; Johnson et al., 2016). In a study of Indigenous Australians, the Short-For Warwick-Edinburg Mental Well-being Scale achieved an internal consistency of a= .69-.88) (Davison, Liddle, Fitz, & Singh, 2020). The WEMWBS has also been evaluated in various minority and cultural groups (Stewart-Brown, 2013).

Visual Analogue Scales: Anxiety, Emotional Arousal, Emotional Valence

Participants will respond to Visual Analogue scales for Anxiety (VAS-A), emotional arousal (VAS-EA), and emotional valence (VAS-EV) during reactivity testing. These items have favourable properties, including construct validity and sensitivity (Abend et al., 2014; Langley & Sheppeard, 1985; Lesage et al., 2012; Reips & Funke, 2008).

Safety: AUDIT-C, DAST-10, SDS-C

The Alcohol Use Disorders Identification Test (AUDIT) reduced a 10-item measure (Skinner, 1982)to assesses alcohol consumption and drinking behaviours in three items, version C (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998). The full AUDIT is translated and validated (Gache et al., 2005). The Drug Abuse Screening Test (DAST) is a 10-item validated self-report scale and will be used to screen for assessing drug use over the previous 12 months (Skinner, 1982; Yudko, Lozhkina, & Fouts, 2007). No information is yet available about the validity of the French translation of the DAST. The Severity of Dependence Scale (SDS) for Cannabis (Martin, Copeland, Gates, & Gilmour, 2006), consists of 5-items. No information is yet available about the validity of the French translation of the severity of dependence scale (Tremblay, Dupont, & Sirois, 1999).

Data analysis

We will use a method of data pre-processing similar to that described in Seon et al. (to *be submitted* in Chapter 2*)* for psychophysiological data. To check if the distributions and do other preliminary analyses, we use R Statistical and Computing Software. We will conduct tests of independence (or non-parametric tests) for categorical variables and other descriptive statistics, such as means/median values. We will use generalized mixed linear models to compare the two treatment groups, and between-group comparisons across several time points. Additionally, we will also describe individual change over time and the correlation between various mood and trauma symptoms. To correlate the questionnaire with psychophysiological data, we will employ non-parametric regression analyses. Additionally, we will explore preliminary cut-scores plotting receiver operating characteristic (ROC) curves and conducting area under the curve (AUC) analyses.

Discussion

This protocol, which compares VR-CBT and Calm Place as self-management, responds to community and research sphere needs. The Inuit community in Montreal indicated their desire for a resilience-based mental health resource and co-designed this project. Additionally, the last few decades of research emphasize the weak generalizability of many findings within mental health intervention—certainly since many are in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) samples (Henrich et al., 2010). Few appropriate health resources have been culturally adapted in-depth or use transdiagnostic factors rather than specific disorders or symptoms. There is a need for more randomized, controlled trial (RCT) evidence for the efficacy of culturally safe interventions (Brooks-Cleator, Phillipps, & Giles, 2018; Leske et al., 2016). As psychotherapies advance technologically, VR-CBT becomes an opportunity for Inuit health. Besides possibilities of remote treatment (or telemedicine), VR-CBT combines a transdiagnostic and effective treatment modality with potentially improved control and immersion into therapy (Cludius et al., 2020; Sloan et al., 2017). For instance, therapists can track real-time psychophysiological responses to therapeutic challenges through biofeedback (Ter Harmsel et al., 2021). Therapy can occur in any environment judged most appropriate by therapist and client to enhance cultural safety and relevance of treatment. The proposed study is a strong design, with an active control and being culturally adapted to its target group. Equally, as this is a pilot RCT any challenges or limitations (e.g., reduced between groups effects) of the study will be better identified. Future work includes extending the therapy as a remote treatment.

Trial Status

This study will be registered prospectively. Recruitment will begin in September 2021 and is set to finish in September 2022.

List of abbreviations

VR: virtual reality

CBT: cognitive behavioural therapy

VR-CBT: virtual reality cognitive behavioural therapy

VAS: Visual Analog Scale

RCT: randomized controlled trial

HMD: head-mounted display

HR/HRV: heart rate/ heart rate variability

SC: Skin conductance

SBP/ DBP: systolic/diastolic blood pressure

DERS-16: Difficulties in Emotion Regulation Scale 16-item

GAD-7: Generalized Anxiety Disorder Scale 7-item

PC-PTSD-5: Primary Care Screen for Post-Traumatic Stress Disorder Diagnostic and Statistical Manual 5 version

PHQ-9: Patient Health Questionnaire 9-item

VAS-A/EA/EV: Visual Analogue Scale- Anxiety/Emotional Arousal/Emotional Valence

CORE-OM/10: The Clinical Outcomes in Routine Evaluation Outcome Measure

WEMWBS: Warwick-Edinburg Mental Well-being Scale

AUDIT-C: Alcohol Use Disorder Identification Test version C

DAST-10: Drug Abuse Screening Test 10 item

SDS: Severity of Dependence Scale for Cannabis

Declarations

Ethics approval and consent to participate

We have submitted for approval a protocol to the Ethics Review Board at our institution. Before participation, we will obtain written, informed consent from all participants or oral consent when a language interpreter is needed.

Consent for publication

Not applicable.

Availability of data and materials

The final trial dataset will be accessible to the researchers of this project, the Inuit community, and those granted access by the Inuit.

Competing interests

The VR environments for this protocol were developed in inVirtuo a company owned by co-author (S.B).

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Authors' contributions

OL is the primary investigator, who conceived the study and led the study development and planning. QS authored the majority of the sections of text. NM, MK, MY, LGC, LK, DJ, CP, SB contributed to the design and development of the protocol. All authors read and approved the final manuscript.

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Chapter 5: Discussion

Is a physiological reactivity testing paradigm feasible?

Portal collected, visualized and extracted signals, some work to increase feasibly needed

As seen in Chapter 1, the quality and information available on the Psychophysiological Signals Portal and its components are critical for its integration into clinical work. Thought Technology is one of the few companies with medical-grade licenses on their biofeedback devices in Canada, which collect, visualize and pre-process psychophysiological signals using their proprietary software. Thought Technology systems are tested and reliable; however, there is a need for both clinician and client-oriented platforms in clinical settings. The Psychophysiological Signals Portal operates on a remote server, which will eventually allow patients to access or communicate in some way with their clinical team through it. Despite some initial challenges, including technical problems and human errors, the psychophysiological signals Portal visualized, stored, and extracted the data of n=20 healthy participants (Chapter 2), with more testing currently under way. Its initial feasibility is promising, but the future implementation in clinical settings will depend simplifying and streamlining several functions in the Portal to increase usability. With some work, the psychophysiological signals Portal will be useful for both clinicians and patients engaging in psychotherapy, even from afar. This means that we will have a more useful biofeedback and clinical outcome system; processing signals and outputting that information to clinicians and clients.

Reactivity testing paradigm links heights and SCR response

The data in Chapter 2 demonstrated the initial usefulness and feasibility of the reactivity testing paradigm. Altogether, the reactivity testing paradigm takes about 40 minutes to complete, using simple VR environments that our co-authors developed. Initial results conformed to our expectations about psychophysiological responses among healthy participants. Prior literature is mixed about whether there are changes in electrodermal activity among healthy controls when exposed to heights (Diemer et al., 2016; Seinfeld et al., 2015). However, our study, which had a direct interest in the effect of heights and used a sample from the general population, rather than a specific occupational group, expands the literature. Our work also supports the findings in studies like Diemer et al. (2016).

More evidence needed to tie arousal and SCR with emotion regulation

While one of my primary research questions involved whether difficulties in emotion regulation are associated with increased objective or subjective arousal to a non-trauma cue, we observed no association between scores on the Difficulties in Emotion Regulation Scale (DERS-16 item) and SCR. The lack of association replicates several previous findings (Zaehringer et al., 2020). Still, it does not entirely rule out emotion regulation's effect on SCR, as there might have been a small effect not detected due to sample size (Webb et al., 2012). (Webb, Miles & Sheeran (2012) observed a small negative effect of expressive suppression on psychophysiology in the meta-analysis).

Changes in *emotional arousal* during reactivity testing were marginally (positively) associated with difficulties in emotion regulation, which supports that using emotion regulation strategies and completing goal-related behaviours could be implicated in reactions to height exposure. Overall, the reactivity testing paradigm gave sufficient evidence of working as planned, creating psychophysiological responses (objective/subjective) among healthy participants; however, we will need further evidence to examine the relationship of reactions to height exposure and emotion regulation.

How can these findings apply to Inuit in Quebec?

No norms of Inuit psychophysiological response to acute stressors

There are not yet established psychophysiological response norms for First Nations, Métis, and Inuit. Considering ethnicity, race and culture in psychophysiology is complex, many shared environmental or genetic traits could influence differences among groups. Though it is important to know about ethnicity and race in psychophysiology (Gatzke-Kopp, 2016), many subgroups exist in the general population because of these and other factors. Thus, the reactivity testing paradigm is meant to bridging the ethnocultural divide in measurement rather than single out specific groups.

So far, there are similarities between resting physiology in Inuit and other subgroups of the population. In a study using wrist-worn devices, n=92, 457 United States adults had a mean daily resting heart rate of 65 beats per minute (range: 40-109) (Quer et al., 2020). Resting-state cardiac activity among Cree, Inuit, Inupiat in Northern Canada (e.g., Nunavik) is on average 73 beats per minute (Alkazemi, Egeland, Roberts, & Kubow, 2012; Dewailly et al., 2001; Beatriz Valera, Dewailly, Anassour-Laouan-Sidi, & Poirier, 2011; B. Valera, Dewailly, & Poirier, 2013). The resting heart rate falls well within North American ranges. According to the World Health Organization, the range for normal blood pressure is 115-120 systolic and 75-80 diastolic (World Health Organization, 2003). Again, Inuit fall within normal ranges, with a systolic blood pressure of around 117 and average diastolic blood pressure of about 75 (Alkazemi et al., 2012; Dewailly et al., 2001; Beatriz Valera et al., 2011; B. Valera et al., 2013). These findings indicate that resting psychophysiological metrics are fairly consistent across the general population.

However, both chronic and acute stressors could affect certain aspects of physiological responses (Kim et al., 2018). Indigenous populations are exposed to pollutants (Liberda, Zuk, & Tsuji, 2021; B. Valera et al., 2013; B. Valera et al., 2012) and have, like everyone, different genetic compositions attributable to race and ethnicity (Melton et al., 2010). Equally, social and emotional well-being (Berger et al., 2017), as well as other acute stressors (e.g., racial stressors) (Hu, Singh, & Chan, 2018; Kaholokula et al., 2012) potentially could create differential autonomic nervous system functioning among Indigenous populations.

Equally, experimental reactivity testing paradigms and their cultural meanings rely somewhat on the chosen stimuli. There is a fair degree of debate on whether heighs reflect a naturally arousing stimulus for everyone or hold some learned (e.g., cultural significance). Among groups consistently exposed to heights, such as construction workers and air traffic controllers, heights evoke fear responses, albeit responses reflecting more resilience to the stressor (Cosic et al., 2019; Habibnezhad et al., 2020). Like sex, socio-economic status, and race, cultural factors may have some impact on psychophysiology (Gatzke-Kopp, 2016). Recognizing inter-individual differences are an important part of psychophysiological science, which can inform individualized treatment and assessment. Arguably, an individualized psychophysiological assessment may offer more robust information than sweeping cut-off values which are typical of psychometric evaluation (e.g., score of 10 on GAD-7 scale for anxiety).

Emotion regulation is more culturally sensitive

A 2021 review by Gall et al. reported resilience (n=21 papers) as a common theme in the well-being of Indigenous peoples in Canada. Strength and activism are closely tied to many Indigenous identities, as it is protective over survival, culture and well-being. In fact, measures that address Inuit and Kanien'kehá:ka needs and ways of knowing include growth and empowerment constructs (Gomez Cardona et al., 2021). Within the framework of mental health, resiliency is decolonizing. Much of the literature in Canada has focused on trauma (Gall et al., 2021). The colonization which created the Canadian nation is ongoing and traumatizing. Communities are missing the Murdered and Missing Indigenous Women, trans Women, Girls, and Two-Spirit people likely at the hands of traffickers and patriarchal ideals and queerphobia (de Leeuw, Lindsay, & Greenwood, 2018; Olson-Pitawanakwat & Baskin, 2020; Razack, 2016). While it is essential to address trauma to enhance well-being, it is not a holistic or empowering view of mental health to minimize it to one concern. Instead, an ideal framework encompasses both mental health and illness may be more ideal. Indeed, Kirmayer et al., 2011 theorized that the adaptive hopefulness for the future tied to Inuit identity and resilience matches with emotion regulation (Laurence J Kirmayer, Stéphane Dandeneau, Elizabeth Marshall, Morgan Kahentonni Phillips, & Karla Jessen Williamson, 2011).

Thus, emotion regulation should be further explored with Inuit, as it may be a more coherent, holistic construct that still maps onto psychophysiological responses. In essence, we will confirm whether responses of healthy Inuit are similar to other healthy populations. Factors such as stressors and strained resiliency, if and when present, could cause dysregulated psychophysiological responses, as characterized by difficulties in emotion regulation (Yang et al., 2021).

Application of the height exposure paradigm to clinical work

We developed the reactivity testing paradigm with both the need for objective physiological measurements and possibilities for its future implementations in mind. At clinics specializing in Indigenous mental health, the reactivity testing paradigm could function as an intake tool. Inuit wellness is a complex, dynamic model composed of emotional, spiritual, physical, mental well-being (Kirmayer, Fletcher, & Watt, 2009). Having an engaging, novel intake tool that “opens the door” to a discussion about of well-being as a holistic entity, clients/patients might feel more understood and happier with their service use.

Take the usual intake format for an example: culturally insensitive diagnostic interviews and self-reported scales give *only the clinician* an idea of the patient’s well-being. Whereas, using culturally adapted/accepted tools in conjunction with the reactivity testing paradigm, clinicians and patients alike may have a whole picture of well-being and any illness. For example, clinicians could use measures like the Growth Empowerment Measure—soon to be culturally adapted by our research team (Gomez-Cardona et al., *in preparation*). Otherwise, the Cultural Connectedness Scale (Snowshoe, Crooks, Tremblay, Craig, & Hinson, 2015) is for use with First Nations, Métis, and Inuit. Both tools encompass a resiliency-based approach. In addition, these tools open discussion to mental, emotional, and spiritual well-being and growth.

Next, introducing patients to the idea that heart rate and other indicators like skin conductance may indicate well-being and any challenges in emotion dysregulation, patients could do the reactivity testing paradigm under the clinician’s supervision. Naturally, many patients would be curious about their responses during the tests—heart rate is almost a lay-term and easily interpretable by most patients. Clinicians and patients could HR and SCR results for the segments and what this could mean. This format is arguably more empowering and engaging for clients. They actively become a part of the testing and discuss with clinicians their experience of the paradigm and what this could mean. It is also more exciting and dynamic than the regular interview or self-rating scale format, engaging patients and hopefully creating a warm patient-provider alliance.

What use are culturally adapted interventions to Inuit?

Inuit expressed a desire for resilience tools

At the beginning of this project, our team reached out to several Indigenous communities in Quebec about the possibility of culturally adapting resilience tools. We had a positive response from the Inuit community in Quebec and formed a partnership. We have incorporated many aspects familiar or useful to Inuit into both the manualized therapy and the VR environments. For one, we created a VR practice place (e.g., in Chapter 4, the Snowy Place) that will serve as a safe and familiar environment for Inuit to practice skills. We aim to incorporate biofeedback in that environment using signals important to Inuit, such as blowing snow and wind, indicating the need to regulate psychophysiological responses. The research team and Inuit advisory committee co-designed how VR-CBT with biofeedback could be acceptable and relevant.

Culturally adapted interventions are needed

In Chapter 4, I described the protocol of a culturally adapted VR-CBT for use with Inuit in Quebec, where we capitalize on the flexibility of VR versus *in-vivo* for therapeutic work, hopefully increasing the relevancy, acceptability, and safety of the treatment. In addition to the Inuit advisory committee and community members expressing the desire for culturally adapted interventions, there is support in the empirical literature. Culturally adapted mental health interventions are better than care as usual (Rathod et al., 2018; Wright, Reisig, & Cullen, 2020)., and, in some cases, even better than active controls like conventional psychotherapy or medications (Anik, West, Cardno, & Mir, 2020).

The primary benefits of culturally adapted interventions are greater acceptability of the intervention and greater treatment adherence (Rathod et al., 2018; Wright, Reisig& Cullen, 2020; Anik et al., 2021). Identifying concerns and treatment with what the client believes would be effective and useful to them is essential. For instance, integrating *cultural idioms of distress* into assessment and intervention can increase their validity (Cork, Kaiser, & White, 2019). The majority of currently culturally adapted interventions may not be suitable for use with Indigenous populations, given their development with immigrant populations (Rathod et al., 2018).

What mental health technology benefit?

The Portal, the paradigm and the VR-CBT for use remotely

All of the technologies in this thesis work, including the Portal, paradigm, and VR-CBT can accommodate remote delivery. Around twelve thousand Inuk live in Nunavik (the Northern third of the province of Quebec). While most of our current efforts involve Inuit in Southern Quebec, there is an interest in adding resources for the North. Inuit in Nunavik have been mobilising their communities despite challenges—what some authors call “resilience in action” (Fraser, Hordyk, Etok, & Weetaltuk, 2019) (title of article).

Around 60% of health services in Nunavik are publicly provided, with traditional psychiatric service significantly deficient (e.g., psychiatrists available at hospitals and other centers from once per week to once every few months). Several voluntary organizations provide health promotion activities, including cultural and crafting activities (Salinas-Perez et al., 2020); however, concerted efforts are still needed. Mental wellness is an action item for the Nunavik Regional Board of Health and Social Services (*Nunavik Regional Public Health Action Plan 2016-2020*, 2017). Data from the Key Health Inequities report showed that suicide mortality was 6.5 times higher in areas with more Inuit (though self-reported mental health was similar to non-Indigenous groups)(Public Health Canada, 2018).

The psychophysiological signals Portal operates on a remote server, and we have plans to make a server available in Nunavik. Recently, some researchers evaluated telemedicine provided by psychiatrists and support staff in the North (Shang et al., 2021). Several psychiatrists expressed that locals needed mental health services and that their current work was through a balance of community workers onsite and psychiatrists. We will recruit Indigenous psychotherapists or psychotherapists experienced in working with Indigenous for the trial. The VR-CBT is a fairly concise intervention, lasting from 7-10 weeks per our estimation. In this way, we could add culturally safe resources remotely with low impact of turnover; the participants would finish therapy when they achieve maximal benefits of the short treatment.

An essential part of tele-mental health is allyship, the psychotherapists may need to visit in person and learn some about the North. However, the remote aspect of the work is still beneficial, as there is increased comfort in disclosing to someone outside of the community (Shang et al., 2021). We could supplement this by having Indigenous or psychotherapists experienced with Indigenous populations and several community liaisons onsite if visits are not possible.

The psychophysiological signals Portal is also advantageous for remote care; several psychiatrists from the previous paper, Shang et al. (2021) noted that a paper-based documentation system was suboptimal. In contrast, users with the proper credentials can access our Psychophysiological Signals Portal from anywhere with a secured connection. Documentation is also easier within the Portal; it currently has note-taking capacities and scheduling. The Portal's future implementations could include a summary page of patient session information and a client-user side for communication or relay of treatment benefits to the client.

Our remote work's potential challenges are finding patients with an appropriate fit (e.g., desiring only a short intervention and with specific clinical characteristics). Given that the therapy builds emotion regulation skills, we would have primarily patients with anxiety, post-traumatic, and depressive disorders, which are the most appropriate group for this kind of treatment (Shang et al., 2021). Equally, a stable connection to the server and the internet are essential to the work, as any technical problems could interfere with treatment or engagement with therapy. Lastly, and most concerningly, projects such as these take lots of time, attention, and work. For the project to be sustainable, staff contracts and budgeting should last past the planned finish date of the program. These kinds of programs are complex thus require significant resources to start, including a multidisciplinary team.

However, the program's benefits could be robust, such as reducing the number of trauma symptoms and increasing emotion regulation skills in the patients. Shang et al., 2021 found that patients were less likely to miss appointments through the assistance of a community liaison, indicating that finding a supportive and familiar presence in the therapeutic encounter is also desired (Shang et al., 2021). Creating familiar environments in VR and carefully formulating our manualized therapy with an Inuit advisory committee, might create a more inviting therapeutic encounter and encourage treatment engagement. Having skills that apply to situations they know—several of which we included in the VR-CBT manual (Chapter 4, **Appendix 1**)—might also mean that they can better cope and apply their therapy to their everyday lives. These therapeutic benefits could also mean less need to return to treatment and greater remission of symptoms.

Strengths and future directions

The pilot study predicted future challenges and effect sizes

Conducting a pilot study is important in mental health research, ensuring that researchers can prepare for any unknowns about an intervention or measurement (Feeley et al., 2009). Moreover, they allow for the calculation of effect sizes to determine the sample size for future work. A clear benefit of the current thesis work was that we evaluated both a novel system and tool, the Psychophysiological Signals Portal and the reactivity testing paradigm. This careful approach meant we identified several key issues and challenges that could affect our data quality. Furthermore, despite a small sample, we observed, for the most part, large effects of psychophysiological response to height exposure, ascertaining that for the future trial, we use a suitable measurement that will detect effects. This is also true of the pilot RCT trial, where we will gradually scale up the efforts once identifying key challenges and treatment effects.

Piloting with healthy participants an important step

In formulating their designs, researchers need to determine which outcome measures will be most appropriate for their sample and if they will be able to observe their predicted effects with the measure (Coster, 2013). We made a careful determination of any biases might arise from the stimuli (e.g., cultural bias) and if the measures would indeed capture the changes we might observe (i.e., choice of VAS and continuous skin conductance). Another careful consideration was the sample. Inuit in Quebec are sometimes susceptible to vulnerabilities; Indigenous people in Quebec experience homelessness at higher rates than the rest of the population (Inuk being 80 times more likely to experience homelessness than non-indigenous people in Montreal (Seltz & Roussopoulos, 2020). We felt that healthy non-Inuit might be an appropriate starting point, given higher social pressures among Inuit and the priority of collecting careful, complete, and accurate data for this group. However, continuing with the investigation of the reactivity testing paradigm with Inuit will be necessary, and we will need to collect more complete data on the acceptability of the paradigm. Nevertheless, the reactivity testing paradigm seems promising, given positive responses by those who have participated in our study so far.

Height exposure straightforward to implement

Both forests and heights are stimuli that are common enough to commercial or other VR products for health care professionals. Thus, it is entirely feasible for any research to replicate or continue this work in virtual reality. Researchers interested in VR either can use already available programs or open-source packages for building VR environments (e.g., VREX, OSVR, VR Juggler, CalVR, etc) (Boger, Pavlik, & Taylor, 2015; Cruz-Neira, Bierbaum, Hartling, Just, & Meinert, 2002; Schulze, Prudhomme, Weber, & DeFanti, 2013; Vasser et al., 2017). Considering that some Indigenous groups, like Inuit in Quebec, were interested in culturally adapted resources, the possibility of building or adapting any VR environment is very beneficial for assessment and intervention.

VR-CBT uses an active control group

Another strength of the thesis work is its response to both research and community needs in Indigenous health. For instance, the protocol plans to include an active control, not simply a waitlist control or treatment as usual condition. As aforementioned, the need and desire for resilience tools with Inuit precludes the use of inactive controls. Equally, several reviews culturally adapted interventions mention few studies use psychotherapy or even any active controls (Anik et al., 2020; Rathod et al., 2018; Wright et al., 2020). Suppose our active control condition, a self-management program, shows any efficacy in reducing emotion regulation difficulties and increasing of well-being. In that case, it is easy and cost-efficient to implement widely, broadening the impact of the trial.

Limitations and future directions

Diminished between-group effects of the VR interventions

On the other hand, having both conditions of the RCT be active controls may diminish between-group effects, making it difficult to attribute treatment effects to any particular intervention. We carefully considered the needs and vulnerabilities of our desired sample, and a waitlist control or treatment-as-usual was just not safe or feasible. In our design, we also collect within-person data. We will track the course of any changes in emotion regulation or psychiatric symptoms even if between-group differences are small. As I explained in previous sections, the primary benefit of culturally adapted interventions is the acceptability and adherence to treatment. A significant finding of the trial would be if many participants complete the minimum seven sessions of the intervention, given racial and ethnic minorities have lower rates of treatment engagement (e.g., higher rates of attrition) (Maura & de Mamani, 2017). So far, many of the available culturally adapted interventions compared to inactive controls have found the treatment more efficacious. Increasing access to treatments that incorporate First Nations, Métis, and Inuit ways of knowing is one of the Calls to Action put forth by the Truth and Reconciliation Committee in 2015 (Truth & Canada, 2015), and the VR-CBT trial will advance those imperatives. In future, larger trials of the VR-CBT could attempt to disaggregate the effects of the interventions through additional control groups.

Indigenous-led interventions are still needed

One consideration for this thesis and the VR-CBT protocol is that while it is co-designed with Inuit, Indigenous-led health care partnerships may be more beneficial to Indigenous communities. There is evidence that Indigenous-led services improve well-being and access to care (Allen et al., 2020). One research group even provided a framework for Indigenous-led co-design in digital technology interventions (Peters et al., 2018).

Recruitment during pilot study is slow

Another limitation is the slow process of recruitment of Inuit we encountered during the reactivity testing paradigm. There is undoubtedly an increased burden on Inuit during the current worldwide COVID-19 pandemic; several Indigenous populations internationally are overburdened by COVID-19 and inadequate response by local governing bodies (Power et al., 2020; Skye, 2020). Recent events in Quebec also illuminate this issue. Joyce Echaquan, Atitamekw mother of seven, filmed live a racist and abusive encounter with healthcare workers as they repeatedly mistreated her, and she cried in distress. Joyce died later that same day. Any mistrust of health care systems is easy to understand, given the current state of Canada's health care systems (Duong, 2021). We operated our study at a psychiatric institute, which may carry additional connotations and barriers for Indigenous populations, such as assumptions about who they are by health service workers or stigmatization for being an Indigenous person (Lavallee & Poole, 2010).

Because of the interest, commitment, and involvement of the advisory group to develop the larger project, the impact of slow recruitment may be lesser once VR-CBT trial commences. We will also have a liaison assisting with the VR-CBT project, facilitating recruitment and retention. Speaking with the local Native Friendship Centre, participants finding their way to the institute (e.g., distance, unknown corner of town) may be a barrier to accessing the pilot study or future trial. We have strengthened our procedure around providing directions and assistance to locate the institute and will continue to do so with a liaison working onsite at the Native Friendship Centre during the trial. Additionally, some participants could not feasibly meet some eligibility and safety criteria, which we reformulated during the pilot study and will reconsider for the VR-CBT trial. In informal conversations following the pilot study testing procedures, no significant burdens or stresses were reported; participants were excited to see the nature environment and reasonably/safely stressed by the height exposure. The pilot study and VR trial require time commitment, resources, and careful consideration of potential barriers.

Conclusion

The objectives of this thesis were to respond to the usefulness and feasibility of various technologies for mental health, including objective measurements and virtual reality (VR). I aimed to establish a psychophysiological reactivity testing paradigm, using virtual height exposure among healthy participants and for use with Inuit. I explained future uses for this paradigm in an article describing the protocol of a culturally adapted VR-CBT. The thesis both identified future issues and opportunities with the technologies, including user-friendliness and the potential to generalize the reactivity testing paradigm. Culturally adapted interventions for Indigenous populations are a priority area, lacking response, and we provide a co-designed option for Inuit. The next steps include continued testing of the reactivity testing paradigm with Inuit and psychiatric outpatients, running the randomized controlled trial for the VR-CBT, and eventually expansion with Inuit in other regions of Quebec.

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Chapter 2: Tables, Figures, Appendix

Table 1: Demographic Characteristics for n=16

Demographic Characteristics	**Participants**
	(N=16)
Sex	
Male	8.00 (50.0%)
Female	8.00 (50.0%)
Intersex	0 (0%)
Age (years)	
Mean (SD)	29.7 (12.5)
Median [Min, Max]	22.3 [19.5, 54.6]
Gender	
Women	7.00 (43.8%)
Men	7.00 (43.8%)
Two-spirit	0 (0%)
Non-Binary	2.00 (12.5%)
Other	0 (0%)
First language	
English	6.00 (37.5%)
French	6.00 (37.5%)
Inuktitut	0 (0%)
Other language	2.00 (12.5%)
English/French or other Bilingual	2.00 (12.5%)

Table 2: Scores on psychometric rating scales

Baseline Clinical Characteristics	**Sum Scores**
	(N=16)
GAD-7	
None	10.0 (62.5%)
Mild	3.00 (18.8%)
Moderate	1.00 (6.3%)
Severe	2.00 (12.5%)
PHQ-9	
None	8.00 (50.0%)
Mild	4.00 (25.0%)
Moderate	4.00 (25.0%)
Moderately Severe	0 (0%)
Severe	0 (0%)
PCPTSD-5	
None	14.0 (87.5%)
Probable PTSD	2.00 (12.5%)
DERS-16	
Mean (SD)	28.0 (9.80)
Median [Min,Max]	26.0 [17.0, 56.0]

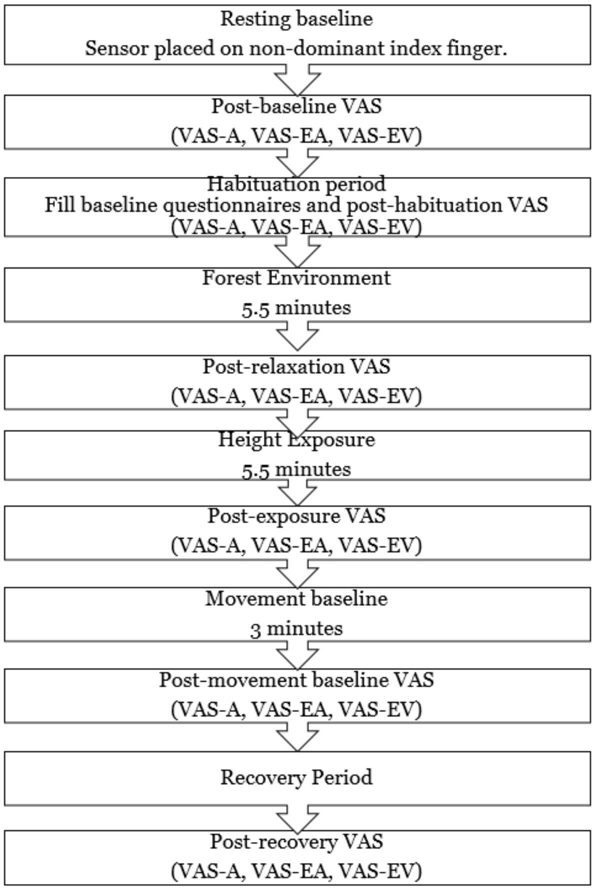

Figure 1: Flow-chart of Paradigm Testing Procedure

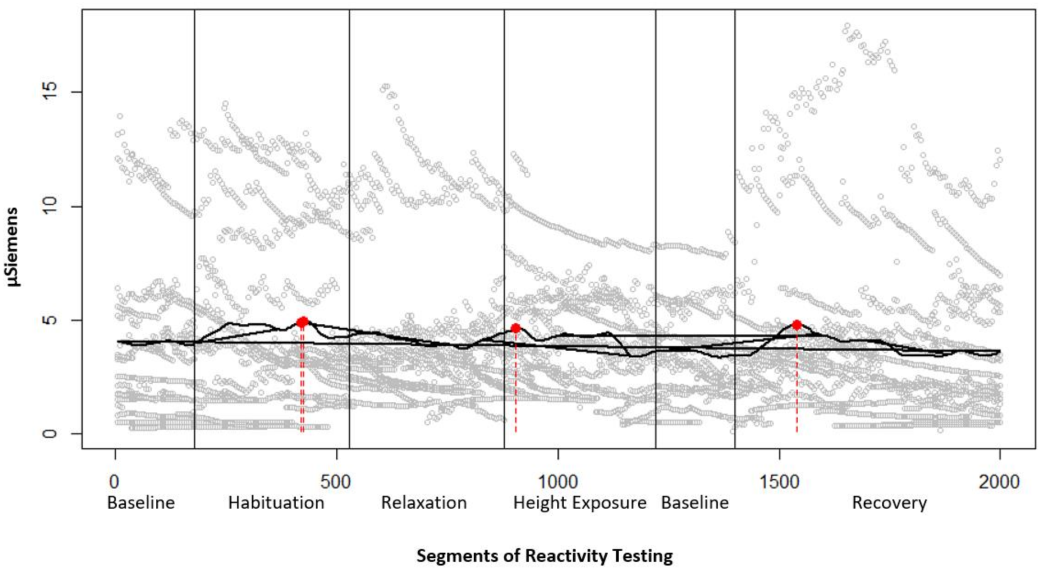

Figure 2: Peaks in skin conductance for n=16 over 2000 seconds of reactivity testing

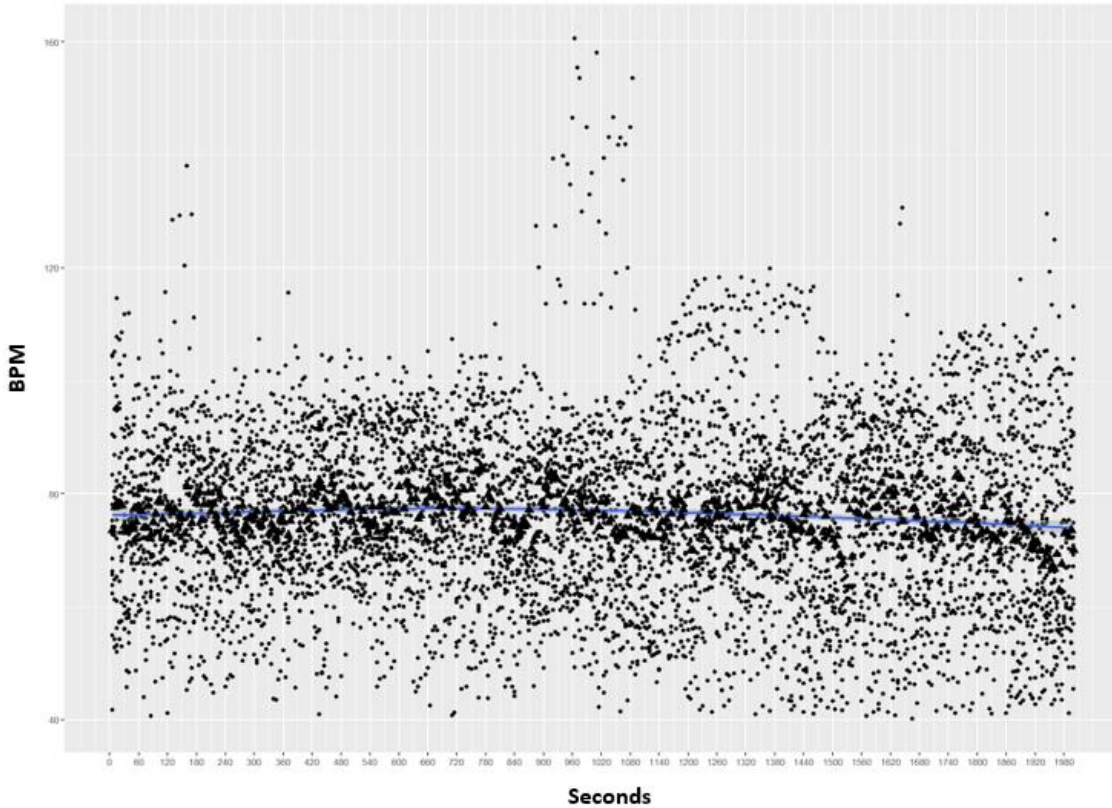

Figure 3: Heart Rate (HR) in BPM over 2000 seconds of reactivity testing paradigm

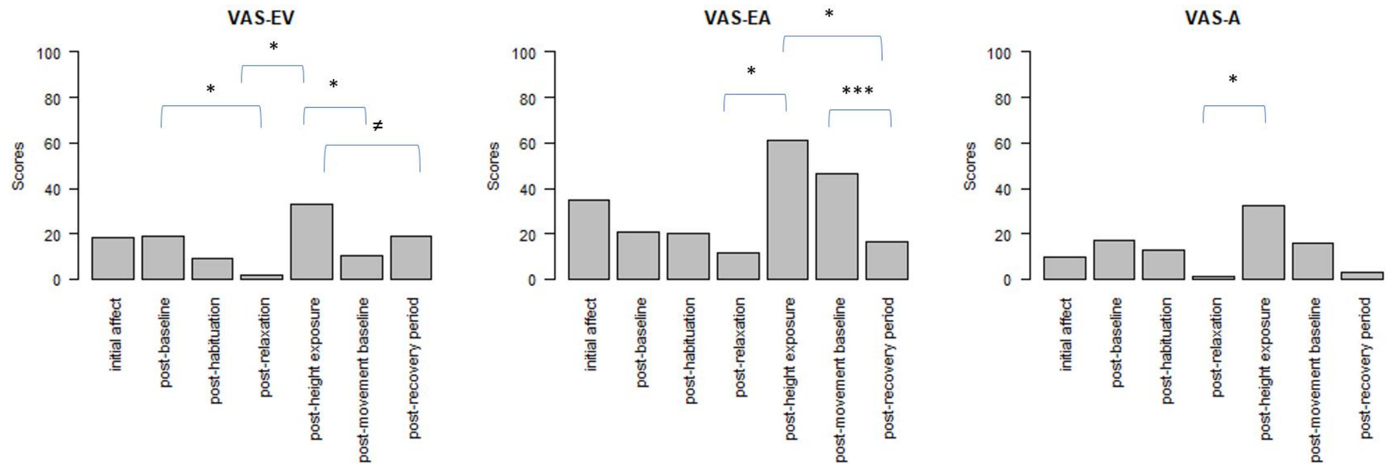

Figure 4: Median scores on VAS items at multiple segments of reactivity testing

Appendix 1: Python scripts for psychophysiological data processing

```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import xlrd
from subplots import intervals
import os

name = str(input("Participant number: "))
directory = os.getcwd()
os.chdir(directory+"/"+name+"/")

#read csv:
df1 = pd.read_csv('sc.csv')
#create a new column for time in mins:
df1['time_minutes']= df1.x/60.00
#mean over 5 seconds:
sc = df1.rolling(5).mean()[4::5].reset_index(drop=True)
#setting lower and upper limits to filter data:
index1 = sc[sc['y']<0.04].index
#values below the limits = NaN:
sc.loc[index1, 'y'] = 'NaN'
#rouding off the time (min) values to 2 decimal places:
sc['time_minutes'] = sc['time_minutes'].round(2)
#saving data to new csv:
sc.to_csv(name+'_filtered_sc.csv', index=False)
#ignoring NaN values and converting data points to floats:
sc = sc.astype(float)
#setting ylims for graphs:
bottom_sc = np.nanmin(sc.y) - 3
top_sc = np.nanmax(sc.y) + 3
#graphing the full data set and then saving:
ax1 = sc.plot(x="x", y="y", color='orange', marker='o', markersize=1, figsize=(20,8))
ax1.set_xlabel("Time (seconds)")
ax1.set_ylabel("Skin Conducatance (microsiemens)")
ax1.figure.savefig(name+"_sc.png")

df2 = pd.read_csv('hr.csv')
df2['time_minutes']= df2.x/60.00
hr = df2.rolling(5).mean()[4::5].reset_index(drop=True)
index2 = hr[hr['y']<40].index
index3 = hr[hr['y']>200].index
hr.loc[index2, 'y'] = 'NaN'
hr.loc[index3, 'y'] = 'NaN'
hr['time_minutes'] = hr['time_minutes'].round(2)
```

```
hr.to_csv(name+'_filtered_hr.csv', index=False)
hr = hr.astype(float)
bottom_hr = np.nanmin(hr.y) - 3
top_hr = np.nanmax(hr.y) + 3
ax2 = hr.plot(x="x", y="y", color='red', marker='o', markersize=1, figsize=(20,8))
ax2.set_xlabel("Time (seconds)")
ax2.set_ylabel("Heart rate (beats per minute)")
ax2.figure.savefig(name+"_hr.png")

os.chdir(directory)

workbook = xlrd.open_workbook('time_segments.xlsx')
time_seg = workbook.sheet_by_name(name)
cell = (time_seg.cell(0, 1))
habituation1 = cell.value
cell = (time_seg.cell(1, 1))
habituation2 = cell.value
cell = (time_seg.cell(2, 1))
baseline1 = cell.value
cell = (time_seg.cell(3, 1))
baseline2 = cell.value
cell = (time_seg.cell(4, 1))
relaxation1 = cell.value
cell = (time_seg.cell(5, 1))
relaxation2 = cell.value
cell = (time_seg.cell(6, 1))
exposure1 = cell.value
cell = (time_seg.cell(7, 1))
exposure2 = cell.value
cell = (time_seg.cell(8, 1))
movement_baseline1 = cell.value
cell = (time_seg.cell(9, 1))
movement_baseline2 = cell.value
cell = (time_seg.cell(10, 1))
spontaneous_recovery1 = cell.value
cell = (time_seg.cell(11, 1))
spontaneous_recovery2 = cell.value

intervals(name, name+'_filtered_sc.csv', habituation1, habituation2, baseline1, baseline2, relaxation1,
relaxation2, exposure1, exposure2, movement_baseline1, movement_baseline2, spontaneous_recovery1,
spontaneous_recovery2, bottom_sc, top_sc, directory)
intervals(name, name+'_filtered_hr.csv', habituation1, habituation2, baseline1, baseline2, relaxation1,
relaxation2, exposure1, exposure2, movement_baseline1, movement_baseline2, spontaneous_recovery1,
spontaneous_recovery2, bottom_hr, top_hr, directory)
```

Chapter 4: Tables, Figures, Appendix

Table 1: Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
Participant characteristics	
• Self-identify as Inuit • Living in Montreal • 14 to 60 years of age • Proficient in English or French	• Non-Inuit • Not living in Montreal • Under the age of 14 or over the age of 60 • Non-functional proficiency in English or French
Physical Risks and Safety	
• Can provide an emergency contact • Tolerance of Oculus headset • Tolerance of sensors • No history of cardiac conditions • No history of epilepsy	• No emergency contact person • Cannot tolerate VR headset • Cannot tolerate sensors • History of heart condition • History of epilepsy
Psychiatric Risks and Safety	
• No suicidal or homicidal risk • No history of psychosis or schizophrenia • Stable mood • Generally mentally stable • Alcohol Use Disorders Identification Test (version C) score $\leq$ 8 • Drug Abuse Screen Test (10 item version) score $\leq$3 • Prescribed psychoactive medications, without change in the past 4 weeks	• Currently suicidal or homicidal • Has experience psychosis or schizophrenia • Mood lability (fluctuations) • Need for hospitalization • Alcohol Use Disorders Identification Test (version C) score $\geq$ 8 • Drug Abuse Screen Test (10 item version) score $\geq$3 • Changes to psychoactive medication in past 4 weeks

Table 2: Psychophysiological Metrics

Setting	Psychophysiological Activity	Variables	Unit of Measurement
Resting state	*Cardiac Activity*	Heart rate (HR) Heart rate variability (HRV) Blood pressure (DBP) diastolic	Beats per minute (BPM) Standard deviations (SDNN) Percent low frequency (%LF) Percent hight frequency (%HF) Millimetre of Mercury (mmHg)
Height exposure paradigm	*Cardiac activity*	Difference in the means of HR	Beats per minute (BPM), Standard deviations (SDNN)
	Electrodermal Activity	Skin conductance	MicroSiemens (µSiemens)
Recovery after exposure	*Cardiac activity*	Time from exposure to resting level HR and SC	seconds

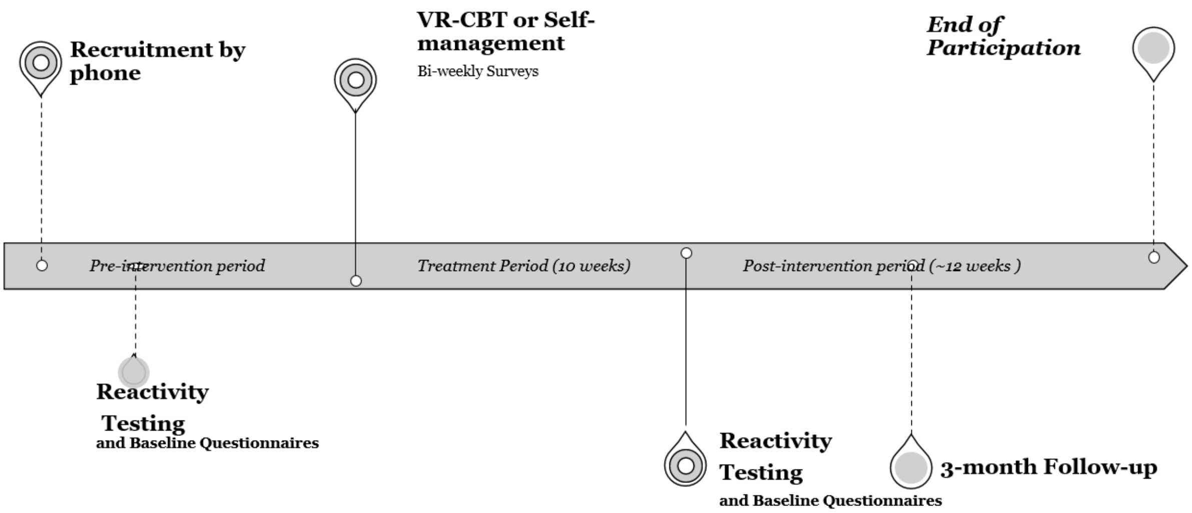

Figure 1: RCT timeline

Appendix 1: Overview of treatment manual

This protocol was designed to be implemented remotely (in video conference) to build resilience in context with the systemic stressors afflicting the Inuit population of Nunavik. Virtual Reality (VR) is used to practice and apply therapeutic strategies that can be usefulto strengthen people's emotional management skills. This program is not adapted for crisis interventions.

The current version of the treatment manual is based on/informed by a validated model of psychotherapy, but has been developed from the beginning in collaboration with our advisory committee. This version is available for a last round of revisions from the advisory committee before being tested in the field. Your feedback is welcome to build afinal version that will be culturally adapted to the Inuit community.

The standardized protocol consists of 10 sessions. Each session is 60 minutes in length and scheduled weekly (or as close to weekly as possible). The majority of each session (40 minutes) is devoted to *Stress Inoculation Training* adapted to develop resilience to threatening adversity by using Emotional Management (EM) skills. The remaining 20 minutes of each session is spent reviewing progresses (at the beginning of the session) and exercise planning (at the end of the session). The program is built on an "explore, show, and do together" model closer to *Guided Mastery* principles rather than classical cognitive therapy approaches. The philosophy of the program is more rooted in action done in VR with the therapist than a "psychoeducational" or an "in-depth talk" therapy model. The focus is not about trauma or past distress, but on managing current emotions.

Session by Session Overview

Session	Topics / Goal
1	Establishing the ground for rapport Setting goals based on a shared understanding Finding personal triggers and current coping mechanisms
2-3	Relaxation to diffuse stressors, take a step back, and relax
4	Putting thoughts and ideas in perspective – Detecting thoughts
5 - 6	Putting thoughts and ideas in perspective – Testing alternative thoughts
7	Problem solving skills
8	Inner-dialogue to challenge and accept thoughts
9	Buffer session (revise or expand skills)
10	Putting it all in practice for the long term

At each session, the therapeutic skills are briefly introduced and then shown and practicedin VR. The goal of using VR is to learn by experience and practicing EM skills, to that theclient can progress to more challenging situations and practice between sessions.

Session	Within Session Sequence
Initial session of the program	Getting acquainted Psychoeducation about how a current sense of threat can emerge fromadversity and the Emotion Management (EM) model. Establishing intervention goals Plan exercise
Core of the program	Review feeling of mastery of the technique and home-based practice.Introduce a skill briefly Practice an EM skill in a neutral context and expand on explanations Practice an EM skill in a stressful context and expand on explanationsPlan personalized exercise between session
Transition to long term gains	Review sense of mastery of the various skills Explore how EM can be blended with other personal coping skills Discuss emotional management over the long term and termination

As part of a research project, the program must be reproducible, however it was also designed to allow therapists to slightly adapt it to the needs and pace of each individual.The therapist must manage time and efforts to ensure all content is addressed in the orderplanned and keep the focus on anxiety and perceived threat. The topics to work on are very focused. We recognize they are somehow narrow given the diversity of needs somepeople may have. However, focus is one of the key reasons why CBT works. In CBT, there is always room for fluidity in the process. *The program is a map to journey toward a better quality of life, not a recipe to be followed blindly*.

Stress Inoculation Training (SIT) for EM in a Nutshell:

How skills will be approached:

1- Introducing and explaining the skill <u>briefly</u>
2- Practicing the skill with the therapist in an easy virtual reality context
3- Practicing the skill with the therapist in a challenging virtual reality context4- Practicing the skill in the real world between sessions with exercises

Which skills will be addressed:

1- Situational awareness – targets identification of triggers and actions
2- Relaxation training – targets current sense of threat and diffusion of crises
3- Cognitive strategies – targets threat beliefs about adversity, oneself and others4- Problem-solving strategies – targets building a variety of coping strategies
5- Inner-dialogue training – targets dealing with acute stressors
6- Closing session – targets self-appropriation, self-efficacy and long term gains