

October 16, 2017

Title: Virtual reality meditation induces health-producing effects in a diabetic patient over 5-sessions (a case study)

Researchers: Singh, R., Rayo, P., Kharlas, D., Lennox, D.

Keywords: Virtual Reality, Diabetes, Heart Rate Variability (HRV), Well-being, consciousness, happiness

Abstract

Type 2 diabetes mellitus is a widespread medical disorder which impacts 6.4% of the world's adult population. The current case study used a combined intervention targeted at symptoms associated with type 2 diabetes such as stress, cardiovascular health, elevated blood glucose levels and high blood pressure. Certain vowel intonations, specialized breathing techniques and a guided virtual reality (VR) meditation were combined into a 5 day intervention. Each day the participant experienced the intervention, while physiological indicators (heart rate variability, blood pressure and blood glucose levels were measured), semi-structured interviews and the PANAS test were used to assess intervention outcomes. The results indicated **positive** improvements. The participant's heart rate variability significantly increased, blood pressure significantly decreased, and the participant indicated increased positive mood and decreased stress. **Personalization** of the intervention is an important technique for optimal well-being and happiness. Future large scale studies are warranted to determine the optimal therapeutic efficacy for this quick, easy-to-use complementary medicine approach for the general population and diabetics.

Purpose

The purpose of this study was to determine whether a combination of interventions can act as a complementary medicine to diabetes treatments in a case study. These interventions include specialized breathing techniques, certain vowel sound intonations, and a guided meditation VR experience. Previous research by Dr. Singh (1997) has found that specialized breathing, intonations, and visualization techniques have important implications for cancer therapy and mind-body healing in general. His research found that these techniques can enhance the

endogenous production of melatonin by the pineal gland. This has important implications for cancer, and well-being. A portion of these techniques were used by cancer patients with insomnia in a study by Absolon et. al. (2016) and results found that there was a significant improvement in participants' quality of sleep. Singh et. al. (2016) conducted a pilot study to observe the potential effects of guided meditation through virtual reality (VR) and they found that this intervention has the potential for people to experience shifts in consciousness, feel calm, peaceful, compassionate, and overall improve mood. This research used that intervention to analyze its effects on diabetic symptoms. It is hypothesized that the techniques used here incorporating virtual reality (VR) will influence blood pressure, heart rate variability (HRV), and glucose levels, thereby improving physiological glucose homeostasis and cardiovascular health.

Introduction

Diabetes mellitus is a group of metabolic conditions characterized by the body's inability to properly metabolize glucose due to its inadequate production of insulin and its struggle to process insulin efficiently, thereby causing serious health problems and poor quality of life and premature death (The Editors of Encyclopedia Britannica, 2017). The Canadian Diabetes Association ("Diabetes Statistics in Canada", 2016) reported that people with diabetes are "over three times more likely to be hospitalized with cardiovascular disease, 12 times more likely to be hospitalized with end-stage renal disease and over 20 times more likely to be hospitalized for a non-traumatic lower limb amputation compared to the general population". In addition, diabetic persons are much more likely than the general population to suffer from stroke, heart attack, kidney failure, and vision loss.

"In 2015, 30.3 million Americans, or 9.4% of the population, had diabetes", additionally "1.5 million Americans are diagnosed with diabetes every year." (American Diabetes Association, 2017) In addition to optimal nutritional therapy, many holistic treatment paradigms have been used to treat diabetes: for example, meditation and yoga practise have both shown to decrease mean blood glucose levels, decrease blood pressure and increase

heart rate variability (Amita, Prabhakar, Manoj, Harminder & Pavan, 2009; Innes & Vincent, 2007). Meditation in particular can be efficacious for decreasing stress, an often overlooked aspect of patients living with diabetes. Furthermore, studies covering the use of stress management techniques such as meditation, yoga or breathing exercises found decreased symptomatology for diabetes patients indicating a relationship between stress and diabetes symptoms (Goyal, Singh, Sibinga et al., 2014; Rainforth, Schneider, Nidich, Gaylord-King, Salerno & Anderson, 2007).

In this study, we incorporated a novel (never done before) technique involving virtual reality (VR) as the tool for assisting guided meditation. Previous studies by Singh, Rayo, Singh (2016) using virtual reality as a guided meditation showed that this method is an easy to use neurotechnology to create in one's inner reality, deep and quick psychologically absorbed states, and higher states of consciousness. The use of virtual reality (VR) as a medium to deliver therapeutic intervention has grown tremendously in the last 10 years and is continuing to grow more and more each year. With the recent advent of consumer grade VR such as a Google Cardboard, Oculus Rift, and HTC Vive, VR has suddenly become a take home therapy. A large amount of recent publications cover the testing of VR for therapeutic use in mental health disorders such as eating disorders, PTSD and phobias. Its efficacy for long term efficacy is unclear but short-term effects seem promising (Gregg & Tarrier, 2007; Reger, Holloway, Candy, Rothbaum, Difede, Rizzo & Gahm, 2011; Maples-Keller, Yasinki, Manjin & Rothbaum, 2017). In particular, one of the greatest therapeutic promises of VR is creating environments in which participants can face their phobias or traumas within physical safety. Also, VR's ability to show extremely realist scenes has the potential to induce deep relaxation or facilitate immersive learning with minimal effort and training.

One application that has garnered quite some interest is using VR for teaching meditative techniques through the creation of immersive VR meditation escapes. This product is called "Guided Meditation VR by Cubicle Ninjas" and it is now available on virtually all major VR platforms (more info at

<https://guidedmeditationvr.com/>). The application allows for users to choose a visual landscape, a background music of choice, and a guided meditation. When all of these aspects are chosen, one is transported into the totality of this experience within VR. Its high level of immersion blocks out all distractions, making it ideal for a focused guided meditation session. Its ability for personalization also allows for greater motivation to continue using the application, as each day the user could choose a different meditation. We took advantage of this to create an intervention design that integrated guided VR meditation with a cutting edge vowel sound intonations and specialized breathing techniques developed by Dr. Ranjje Singh (1997).

Certain vowel sound intonations or mantras are vocally emitted. The practice of intoning certain syllables has been used by various cultures and religions around the world throughout human history, such as the Ancient Egyptians, Islamic groups, Sufis, and Hindus (Singh, 1997). Traditionally, these intonations were used for healing and devotional purposes related to their spiritual beliefs. Today, researchers are investigating the therapeutic value of vowel sound intonations. Pramanik, Pudasaini, and Prajapati conducted a study in 2010 to examine the effects of a specialized breathing technique called Bhramari pranayama, which includes the intoning of the word “O-U-Mmmma”. After 5 minutes of this technique, participants’ systolic and diastolic blood pressure resulted in a significant decrease and a minor decrease in heart rate. Additional detected physiological effects of intoning include increased nitric oxide levels, increased lymphatic circulation, endorphin and oxytocin release, and increased melatonin levels (Goldman & Goldman, 2017). Massion et. al. (1995) showed that mindfulness meditation increases the physiological levels of melatonin. They explain the importance of melatonin as “Melatonin may be related to a variety of biologic functions important in maintaining health and preventing disease, including breast and prostate cancer.” (Massion et. al., 1995, p. 39). Singh (1997) also found in his research that meditation increases melatonin production. He explains that melatonin is considered one of the most important hormones because it has the ability to cross all cell membranes in order to protect sensitive DNA from

oxidant damages. Additionally, researchers have found that this hormone is capable of doing much more and it is now known as the antioxidant, anti-cancer, anti-insomnia, anti-psychiatric, age-reversing, and anti-stress hormone.

Furthermore, McCraty, in the chapter, *The Energetic Heart* (2015) described the relationship between HRV patterns and emotions. In particular, McCraty discussed our hearts as having different ideal functional states, you can measure these states through heart rhythm coherence. Heart rhythm coherence reflects the degree of synchronicity between sympathetic branches and parasympathetic branches of the ANS, leading to increased optimal respiration and healthy levels of blood pressure. There were also psychological benefits to increased heart coherence such as cognitive performance, mental clarity, emotional stability and well-being. Increased heart rhythm coherence was one of the identified effects of meditation and this is shown through heart rate variability measures (Rosch, 2015).

The physiological effects of meditation and spiritual practices have been further explored in PET and Fmri scan studies that consistently find increased activation of the anterior cingulate cortex, which is a region of the brain associated with CNS and ANS changes similar to those shown with heart rhythm coherence. Studying this region of the brain seems to show more detailed representation of spiritual or mystical states that may arise as a result of meditation or similar techniques. They seem to have a positive downstream effect on the functions of the CNS, ANS, and neuroimmuno-endocrine cellular systems, in many of the same ways that they impact heart rate rhythm coherence. (Newberg & Waldman, 2010; Armony & Vuilleumier, 2013). Rossi (1993) in “Psychobiology of Mind Body Healing” also developed an elegant model to illustrate how CNS/ANS activities influence the neuro-immuno-endocrine-cellular-DNA systems in the body.

This intervention emphasizes the personalization of background music to set the mood of each intervention. Previous studies have found profound therapeutic effects from music based interventions. In particular, the ability to use music for mood regulation or induction has been well studied, this can then be used therapeutically to set the

tone of an intervention. For example, cognitive reorientation states that a positive affective experience may render the individual accessible to cognitive change in therapy, this technique's efficacy is discussed in detail within the Handbook of Music and Emotion (2010). Musical therapy has been applied to the treatment of depression, children with language delays and burn victims (Clark, 1983; Robb, 1996; Bunt & Pavlicivec, 2001). Therefore, in this study we explore the use of music to cognitively reorient a participant towards greater health outcomes in VR meditation sessions.

This intervention was used in this single subject case study with a type 2 diabetes patient for 5 days. The patient was a 60 year old female who had type 2 diabetes for 20 years and is not managing her diabetes with any other treatment modalities other than medication to regulate her glucose levels. She was using a number of medications which can be found in Appendix A. She has had some previous experience with meditation but no consistent personal practise. She is a devout catholic. The participant was motivated to try novel treatments for her diabetes symptoms.

Heart rate variability (HRV) was measured to identify changes in overall well-being as HRV has been used in the past to indicate whether meditative experiences influence improvements in overall cardiovascular health. Higher HRV is an indicator of improved cardiovascular health. This is the case as improvements in HRV demonstrate increased flexibility in dealing with cardiovascular stress both physical and psychological which is an important indicator for general well-being (Stein, Barzilay, Chaves, Traber, Domitrovich, Heckbert & Gottdiener, 2008). Blood pressure and blood glucose levels were also both measured. Abnormally low or high than normal glucose levels is a symptom of Type 2 diabetes. Furthermore, the PANAS (Watson, Clark & Tellegen, 1988) was used to indicate any changes in mood experienced by the participant. This battery of psychological test measurements were followed up by a semi-structured interview to assess the experience of the patient throughout this novel treatment intervention.

Hypotheses

Diabetes has been shown to cause decreased cardiovascular health, increased glucose levels, increased negative affect, decreased positive affect and cause elevated levels of blood pressure. Our interest is in studying how certain vowel intonations and specialized breathing exercise combined with a virtual reality meditation intervention may mitigate some of the symptoms of diabetes.

It is hypothesized that this intervention will:

1. Increase HRV (an indicator of greater cardiac health).
2. Decrease glucose levels.
3. Improve positive mood as measured by the PANAS and by perceived changes shown through a semi-structured interview.
4. Decrease high blood pressure to a more normal baseline.

Research Methodology

Instrumentation

Consent form. The consent form was required for participants to consent to the entire study. This form contained a brief description of the study, along with the procedure and a brief summary of what is required from the participant. See Appendix A.

Brief Medical History Form. The medical history component was necessary to inform the researchers of the participant's unique case, including the type of diabetes that the participant is diagnosed with. See Appendix B.

Polar's H10 Bluetooth chest sensor. Heart Rate Variability (HRV) was measured using Polar's H10 Bluetooth chest sensor attached to a polar pro strap. This sensor estimates blood volume at the chest and from this infers the HR signal to calculate the PPG (photoplethysmograph) and RR interval (the length of time between the R peaks of consecutive QRS complexes) of the HR. The Polar H10 is a wireless device that uses Bluetooth to connect

to a mobile device such as an iPad or smartphone. The sensor outputs all RR intervals. The data was then sent to the iOS application Heart Rate Variability Logger through the iPad to calculate HRV stats such as RMSSD, LF and HF frequency. This was then exported to Kubios followed by SPSS for further analysis.

Oximeter. This device was used to check for the participant's sugar levels. The participant recorded her own sugar levels 3 times a day for 2 weeks prior to the study, for the duration of the study, and 2 weeks after the study. A comparative analysis was used to determine changes in sugar levels from pre-, interim, and post-intervention.

Omron BP786CAN 10 Series Upper Arm Blood Pressure Monitor. This device was used to measure the participant's blood pressure before the intervention and after the intervention. The data from pre and post intervention will be compared to detect changes in blood pressure.

Virtual Reality (VR) Equipment. The Oculus Rift equipment was used for virtual reality to provide the participant with an immersive computer-simulated reality.

VR Guided Meditation app. The VR guided meditation app was used for this study, which included a variety of environments for the participant to choose from. Some examples of available scenes are a jungle, a cave, a beach, a cliff, and a canyon. As for the audio, the participant had the option of choosing one of the many guided meditations available, ranging from zen meditation to compassion meditation. There was also an option to choose from one the several music ambiences available in the app. The participant was free to choose from the audio/visuals each day of the intervention. See <https://guidedmeditationvr.com/> for this VR meditative experience.

PANAS Mood Scale. The Positive and Negative Affect Schedule (PANAS) is a self-report questionnaire that consists of two 10-item scales to measure both positive and negative affect. Each item is rated on a Likert scale of 1 (*not at all*) to 5 (*very much*). Example items include: "*rate from 1 to 5 how interested you feel.*" "This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the

number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment OR indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)". This questionnaire is found in Appendix C.

Semi-Structured Interview- A semi-structured interview was administered to the participant after the intervention each day. This interview was guided by 12 topics, which are outlined in Appendix D.

Procedure

This study ran over the course 5 days total at the 7D Health laboratory. The daily intervention was divided in 2 exercises: 1. breathing techniques and vowel intonations, and 2. VR guided meditation. The total estimated time for the intervention at the lab was approximately 2 hours from start to finish. During this time, the participant also signed a consent form to participate in the study and completed the brief medical history form.

The participant came into come into the 7D Health laboratory starting on July 17th 2017 until July 21st at 10 A.M. for each of the 5 days of the intervention. Upon arriving to the 7D lab, the participant was asked to complete the PANAS mood scale in the format of pen and paper. The researchers then took the pre-intervention measurements, including blood pressure and HRV. Since the HRV equipment is a chest strap that must be worn beneath one's shirt, the participant was instructed to go into the bathroom and carefully place it on herself. The participant wore the HRV chest sensor throughout the entire study as HRV data was collected 5 minutes prior to the two exercises, during the exercises, and 5 minutes after each of the two exercises. The blood pressure equipment was affixed by the researchers.

Prior to the first exercise, the participant's blood pressure and HRV was recorded. During the exercise, the participant was guided through the breathing technique and the vowel intonations by "Self-healing", a CD created by Dr. Ranjje Singh in 1997. During this time, the participant intoned 3 special vowel sounds: 1. MER (as in Mirr) 2. EHM (as in Aim) 3. KHEI (as in Kayee). The researchers stepped outside of the room and closed both doors at

the lab during this time so that the participant would not feel disturbed while she was going through the breathing exercise and intoning the vowel sounds. The HRV continued recording throughout this exercise. After 15 minutes, the researchers came back into the room to record the participant's blood pressure and post-intonations HRV.

After the first exercise, the participant was asked to continue sitting comfortably while the researchers recorded a new data set of blood pressure and HRV for the following exercise, the VR guided meditation. First, they showed the participant how to use the VR equipment and then the participant to choose the audio/visuals for the meditation. Throughout the VR guided meditation, the researchers stepped outside of the room again but continue recording the HRV. This exercise lasted about 5 minutes but the whole set up and choosing of the meditation took approximately 15 minutes in total. The participant's blood pressure and HRV was then recorded again for 5 minutes after this last exercise.

After the second exercise was completed, the researchers helped the participant take off the VR equipment and the participant was asked to go into the bathroom to take off the HRV equipment. The participant was then interviewed by the researchers about her experience, followed by filling out the PANAS mood scale one last time. Finally, the participant was thanked and escorted out of the lab when the procedure was complete. This whole process will be repeated once a day for 5 days. When all the data was gathered, the researchers analyzed the quantitative data with SPSS using T-tests and compared the qualitative data to the quantitative data for further exploration of the results.

Results

Summary of findings

The results of this case study supported each of the above hypotheses.

- I. HRV was significantly **increased** following the practicing of the VR meditation. This was demonstrated through the consistent increase of RMSSD values (a statistic that indicates changes in HRV) both during and after the VR meditation each of the five days.
- II. Glucose levels significantly **decreased** following the intervention
- III. Although the PANAS did not show any significant changes in positive or negative affect, the results of the semi-structured interview demonstrated that the participant felt happier, more relaxed and less stressed. This indicates a perceived **increase** in positive affect and perhaps a decrease negative affect, although further research is needed to confirm this.
- IV. Blood pressure significantly **decreased** during and following the intonation exercises

Section 1 – Key Findings in T-test analysis

HRV (RMSSD)

1. Pre-VR compared to Post-VR

- a. A paired samples t-test was done to compare Pre-VR and Post-VR HRV(RMSSD) values over 5 days. It was found that there was a significant increase in the HRV (RMSSD) value when comparing between Pre-VR ($M = 8.34, SD = 2.00$) and Post-VR ($M = 12.06, SD = 2.48$), $t(4) = -13.29, p < 0.05$.

This indicates that consistently over five days after using the guided meditation VR application the participant had on average an increase in RMSSD heart rate variability which is consistent with other studies which also found short-term increases in HRV as a result of following a guided meditation.

Glucose levels

1. Pre-intervention compared to post intervention

- a. A paired samples t-test was done to compare levels of glucose before and after the intervention. It was found that there was a significant decrease in glucose levels after the intervention, when comparing pre-intervention glucose ($M = 8.07$, $SD = 1.10$) and post-intervention glucose ($M = 6.20$, $SD = .87$), $t(2) = 6.42$, $p = .023$.

PANAS

1. Positive affect or negative affect (pre-intervention vs. post-intervention)
 - a. A paired samples t-test was done to compare Pre-intervention and Post-intervention positive affect and negative affect scores on the PANAS score over 5 days. No significant differences were found between pre and post scores for either affect scores, inconsistent relationship with positive affect may indicate that the participants' base mood when entering the study each day may have had more impact on the measurement of mood than the intervention, more data points would be needed to be sure. Negative affect scores stayed very consistent throughout the five days indicating a very low negative affect score, furthermore, it is indicative that the participant did not experience mood affecting frustration as a result of the intervention.

Blood pressure

1. Pre-intonation systolic and diastolic vs post-intonation systolic and diastolic
 - a. A paired samples t-test was done to compare pre-intonation and post-intonation blood pressure values (systolic and diastolic) over 5 days. It was found that there was a significant decrease in blood pressure for pre-intonation systolic ($M = 123.20$, $SD = 6.42$) and post-intonation systolic ($M = 112.80$, $SD = 8.79$), $t(4) = 3.40$, $p = 0.03$. It was also found that there was a significant decrease in blood pressure for pre-intonation diastolic ($M = 77.20$, $SD = 5.98$) and post-intonation diastolic ($M = 73.80$, $SD = 4.50$), $t(4) = 4.54$, $p < 0.01$.

This indicates a consistent decrease in blood pressure across the five days because of the intonation intervention. There were also a trending effect of general decrease in blood pressure because of the entire intervention however, these effects are unlikely to be significantly greater than the effects of the intonation intervention on its own.

Section 2 - Graphical representation of findings

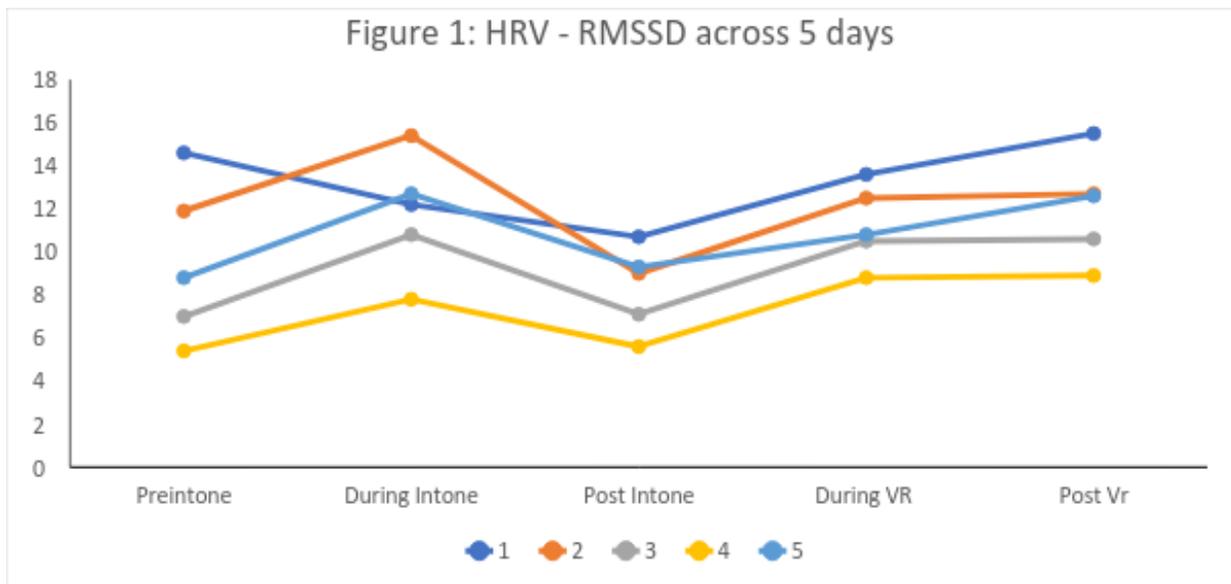


Figure 1. The HRV figure demonstrates a consistent relationship on each day. The participant generally started each day of the intervention with a lowered HRV, it increased during the intonation but this effect was lost directly after the intonation dropping to levels lower than the pre-intone levels, and the VR meditation consistently led to the highest HRV increase, which continued to increase following the meditation. This is consistent with literature on the effects of meditation on HRV and shows a relationship between the practise of virtual reality meditation and its positive benefits on heart rate variability.

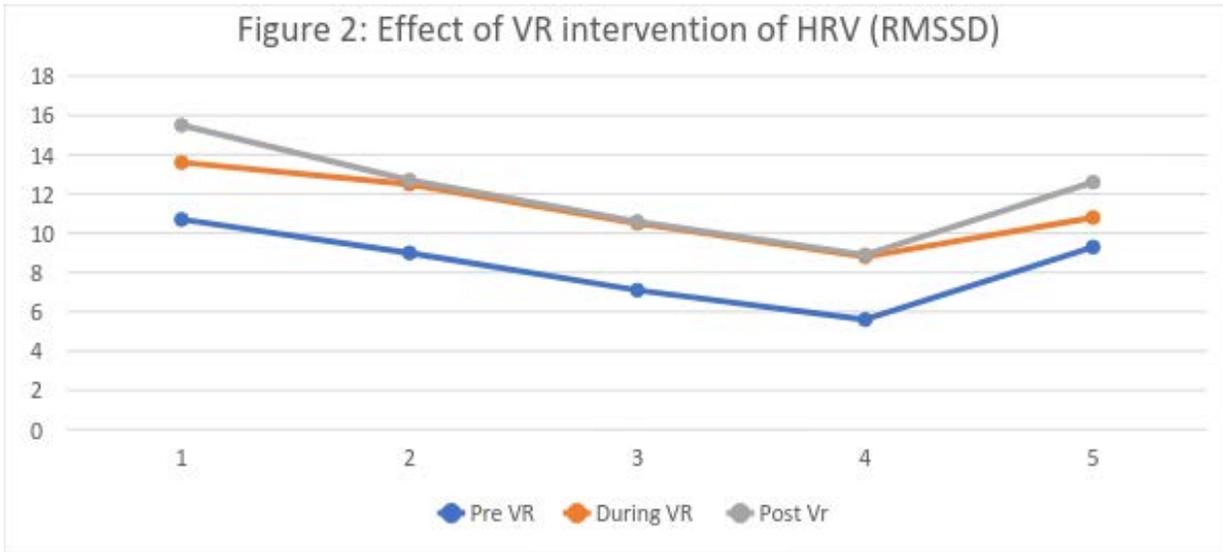


Figure 2. Demonstrates the effect of the component of the guided meditation on consistently increasing HRV levels both during and after the VR meditation. This likely accounts for the increase in HRV caused by the intervention.

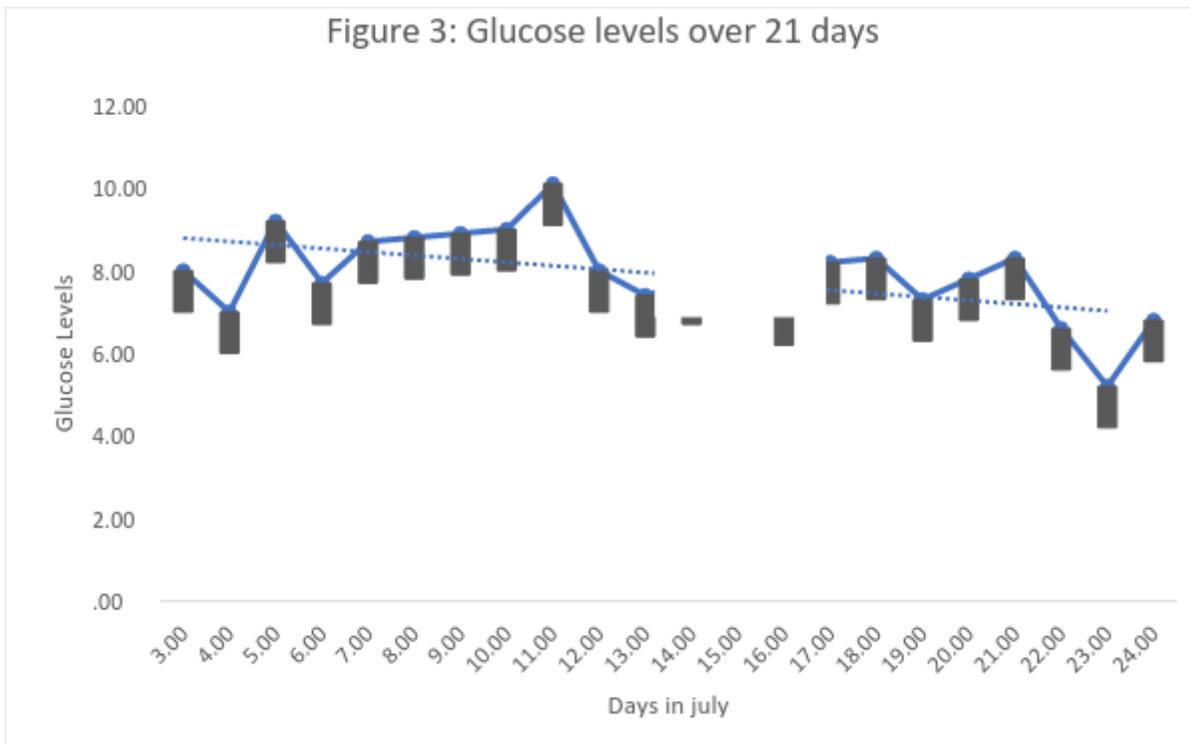


Figure 3. A decrease in glucose levels post experiment may indicate some short-term effects of the intervention on glucose levels however more data is needed to explore this hypothesis. Furthermore, the slope of the graph indicates a trending decrease as a result of the significant decrease in glucose both during and after the intervention.

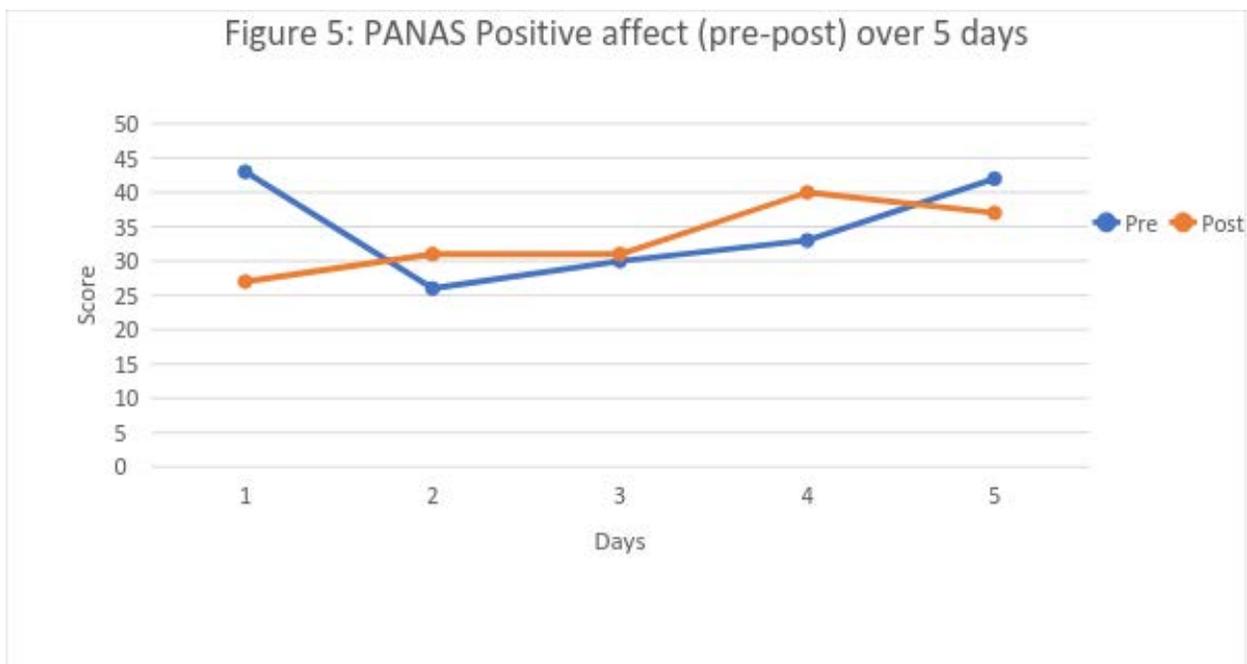
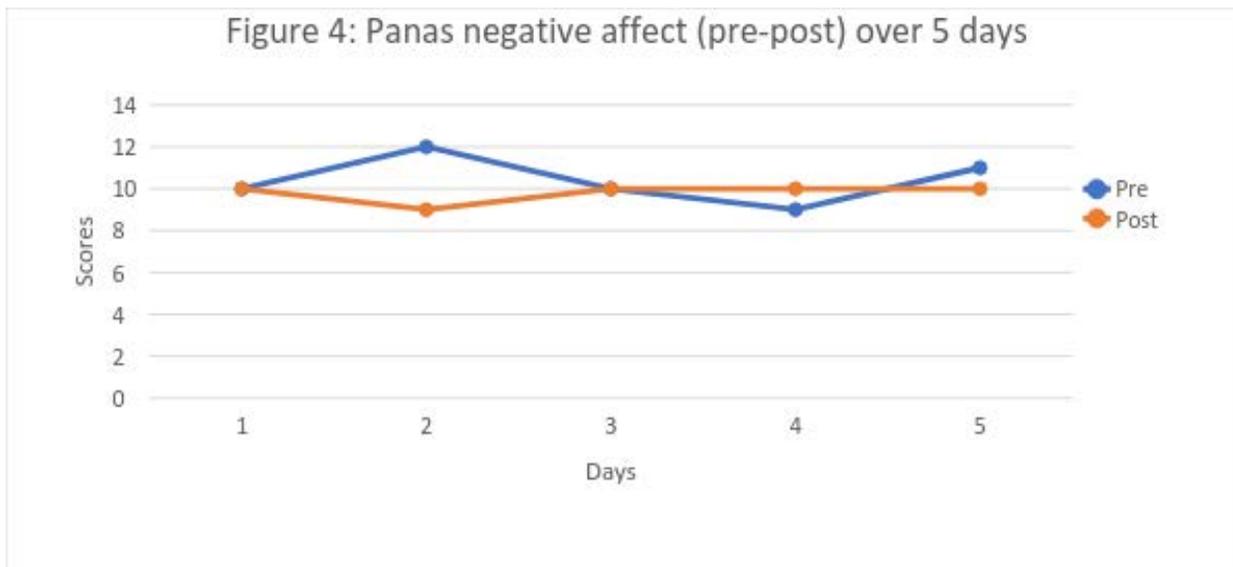


Figure 4 & 5. No significant effects were found in the PANAS questionnaire, nor is there any trending effects.

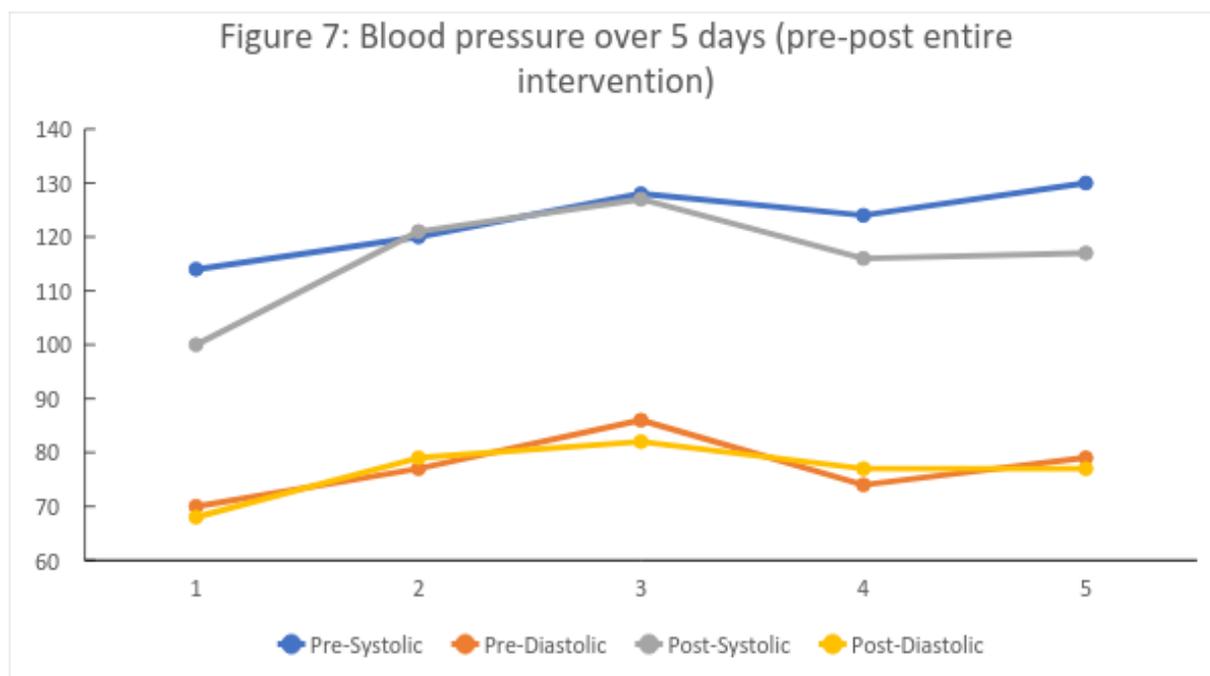
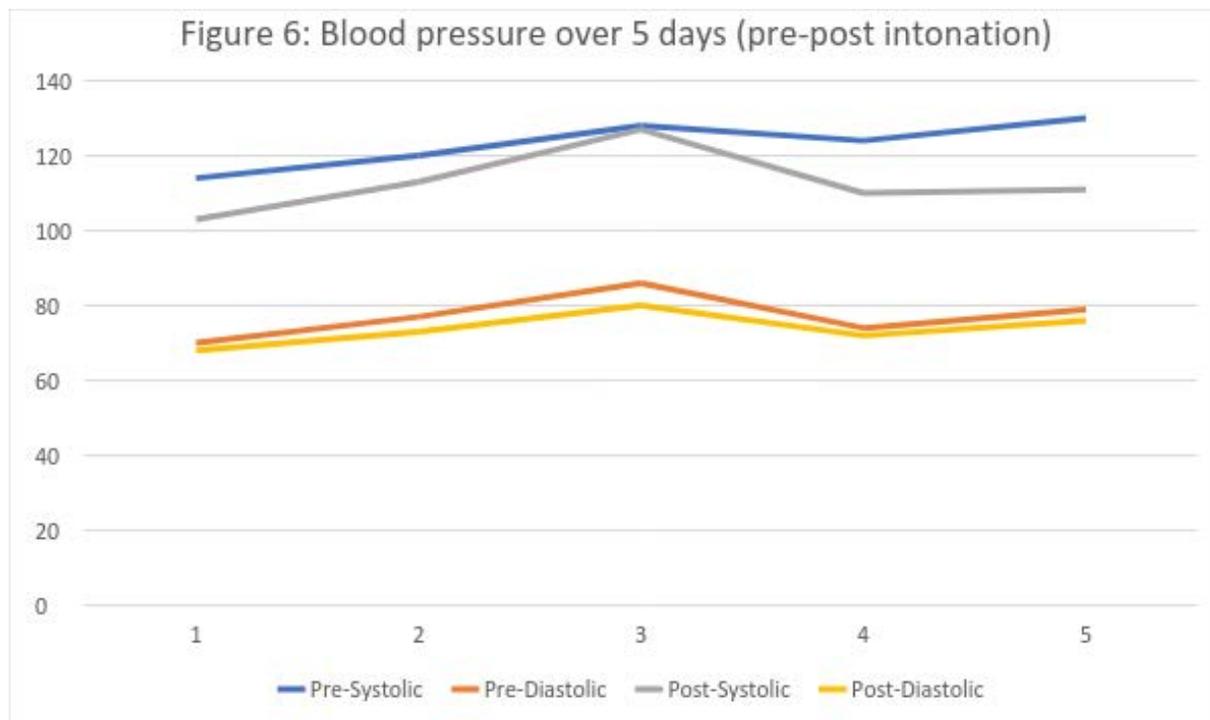


Figure 6 & 7. Significant effects of the intonation intervention likely led to decreases in blood pressure as shown in

the decreased systolic blood pressure after the intonation intervention when compared to before the intervention. The effect of the intonation aspect of the intervention likely accounted for the decrease in blood pressure shown from the entire intervention. Further analysis will tease apart this relationship.

Section 3 - Qualitative Interview Analysis

Summary of analysis

We predicted that the participant would experience increased relaxation and joy as a result of practicing VR meditation, vowel intonations and specialized breathing exercises. The following qualitative analysis has indicated support for our hypotheses; the intervention (including the vowel intonations, breathing exercise, and VR meditation) has been shown to have an overall positive effect on the participant's disposition. She described herself as having more energy, being more joyful, more open, and more relaxed. She expressed that the effects of the interventions have improved her ability to deal with stressful situations in her everyday life, another important finding.

From her perceived improved mood and greater relaxed state, we can conclude that the participant enjoyed the intervention and perceived herself as gaining benefit from it. This is an important finding as it indicates that the intervention was well-designed and was able to meet the needs of the participant. It indicates a need for further testing in a larger population of participants with diabetes. Further testing would allow us to see if this may be an effective intervention for the public and diabetic patients generally to improve mood, induce relaxation and decrease stress in everyday life.

Breakdown by day Summary (see Appendix A for full details of each day)

Day 1

- The participant felt that the experience overall today was “interesting” and “calming”.
- The VR guided mediation was “very fine” but she is **adamant** about the benefits of personalizing the

experience.

- She described her overall view of the day as, “very nice”.

Day 2

- The second day for the participant was more enjoyable for her compared to the first day. She felt that today’s experience was “fabulous”.
- “I was peaceful, I was calm, I feel energetic. It can put you in a totally different frame of mind to carry out your day.”

Day 3

- Today the participant seems more energized and upbeat.
- She was very happy with her experience today, she felt the background music was “superb, beautiful and very uplifting” and really took her into a place of deep calm, “the music today could really take you deep... you don’t have to think about anything else. I pictured myself going to the altar, you know, to see God.”
- Today there is a major shift in the participant in terms of her openness with her emotions. She is sharing more about her personal life, of some of the struggles and events that have deeply troubled her (i.e. emotional catharsis).

Day 4

- Today’s experience for the participant was “fabulous – soothing and peaceful” and the music was “beautiful”.
- She feels that today was much shorter than the previous days, as though she just arrived. This is a positive reflection and suggests that she is calm, at ease, and enjoying her experience.
 - This sense of “time gone” suggests there was a shift from objective state of consciousness to a subjective and subconsciousness state of consciousness in deep meditation.

- The meditation felt more personalized for her as she loves temples and ancient settings.

Day 5

- Today the participant felt the VR experience was very energizing.
- She enjoyed watching the movement of the water and expressed that she did not want to come out.
- Today she felt as though the experience was completely personalized to her and the whole intervention resonated with her more so than the other days
- She had mentioned that she loves piano music and loved the background piano piece we had chosen. She expressed that the last two days were really phenomenal experiences and ranked yesterday (Thursday) as her favourite. She felt that the hour intervention yesterday felt like 5 minutes and today felt like 15 minutes
- Today, her disposition is quite jovial, just as yesterday. She was happy and laughing while reminiscing on time spent with her daughter.

Discussion

This case study found that the participant experienced increased joy and relaxation as a result of the whole intervention; her blood pressure and glucose level decreased likely as a result of this combined intervention; HRV increased as a result of the intervention. These observations could have occurred as a result of decreased sympathetic activity and increased parasympathetic activity in the body caused by the techniques practised in the meditation (Goyal, Singh, Sibinga et al., 2014; Rainforth, Schneider, Nidich, Gaylord-King, Salerno & Anderson, 2007). The participant described her experience throughout the experiment as learning new tools to cope with the stress of her life, and her physiological measurements seem to indicate preliminary results for a positive effect on blood pressure and HRV. A longer intervention could have further decreased the participants blood glucose levels, as was shown in Hur, Han & Cho (2014) when they measured the effect of a meditation intervention on glucose levels.

Decreased Blood Pressure

The practise of intoning traditional Rosicrucian vowel sounds to help decrease blood pressure may be a promising avenue for further cardiovascular health and diabetes treatment research. One study of using sounds and slow paced breathing to decrease blood pressure has been explored in the past through the usage of “bhramari pranayama” techniques, which are a combination of specialized breathing and humming exercises. Bhramari Pranayama has been shown to be efficacious for decreasing blood pressure, another study found asking participants to hum “Om”, a sound often practised for its vibrational properties was effective at demonstrating decreases in stress as shown through FMRI scans of areas in the brain implicated in stress induction and relief (Pramanik, Pudasaini & Prajapati, 2010; Kalyani, 2011). Indeed we found results in this study that indicate a similar effect of blood pressure decreasing following a humming exercise combined with specialized breathing, in this case the vowel intonation practise. The mechanism of vowel intonation practises or vibrational healing may be partially explained through increases in the release of nitric oxide (NO), one of the most well-documented changes that occur as a result of vibrational sound practises. This was found in a study by Weitzberg and Lundberg (2002), revealing that humming greatly increases the amount of NO released in the nasal cavity (the chambers most easily resonating during these practises). NO is interesting because it causes the widening of blood vessels and therefore, leads to increased blood flow and decreased blood pressure (Goldman & Goldman, 2017). Widening the blood vessels through NO release can also lead to greater long term cardiovascular health if this practise is continued over time. Previous research found increased NO release was correlated to cardiovascular health, although this research may not directly relate as the intervention in this research was focused on physical exercise. The connection between NO and cardiovascular health has been well researched and summarized by Nava, Noll and Luscher (1995). NO is implicated in many downstream effects on how blood is pumped throughout the body but especially with how it is pumped into the heart. This therefore means that large changes in how NO is functioning in the body

can have a large impact on cardiovascular health and blood pressure.

If future research reveals that increases in NO is related to many different cardiovascular related interventions then perhaps vowel intonations may turn out to be working on a similar mechanistic function as physical health and may be an especially effective intervention for those with lower mobility. Further research has explored the effect of NO as an explanation for some of the direct health benefits of diets high in certain fruits and vegetables. Specifically, it was found that dietary nitrate, derived in the diet primarily from vegetables, could contribute to cardiovascular health via effects on nitric oxide (NO) status. All of this literature seems to point to the positive benefits of nitric oxide especially when produced endogenously. It seems that vowel intonation practises may increasing endogenous nitric oxide and in this study that may have resulted in decreased blood pressure. This effect should be further studied and is well worth further investigation to see if this is truly the case.

A plausible mechanism of the impact of meditation, vowel intonations and specialized breathing may be connected to the findings explored in Sanada et al., systematic review of mindfulness based interventions (MBI's) impact on biomarkers in healthy and cancer patient populations (2017). This recent systematic review found across 13 studies consistent significant findings of changes in neuropeptide Y, C-reactive protein (CRP) and neuropeptide insulin-like growth factor 1 (IGF-1) as a result of a MBI's. Neuropeptide Y has been implicated in the recovery process of the brain from physiological and psychological stress. IGF-1 has been found to have neuroprotective properties and may improve long-term functions after brain injury (Guan, 2011). Furthermore, IGF-1, also known is known to be a growth factor that mediates cell growth and development. As the MBI techniques focused on breathing, emotional awareness, and cognitive moment-by-moment awareness, increased IGF-1 levels may therefore be related to the enhancement of cognitive function, and to cancer prevention. This relationship between IGF-1 and cancer prevention was found in Levine et al., 2014. Furthermore, CRP may be related to cancer prevention as decreased proteins such as CRP, may be useful in cancer prevention for middle aged populations

according to Levine et al. Interestingly, there seems to be a yet unexplored relationship between CRP and body mass index, indicating a possibly exciting relationship with MBI's and Type 2 diabetes. Specifically, if body mass index could be impacted by increased CRP positively, risk of type 2 diabetes is also likely to decrease. Taken together changes in these biomarkers indicate plausible mechanisms for how the downstream effects of MBI can be tracked by changes in neuropeptides and proteins. The systematic review was heavily limited by the number and quality of studies that currently exist in this field of biomarkers and MBI's. Further studies should continue exploring biomarkers to find more consistent findings across studies to perhaps work towards a meditation intervention focused network of protein and neuropeptide effects that explain the psychological and physical benefits of meditation.

Increased HRV

Our current study found that our participant had increased HRV and self-reported increases in relaxation and happiness as a result of the meditation. Previous research has demonstrated a relationship between the CNS, ANS, medulla oblongata, vagus and phrenic nerves and the parasympathetic branch of the autonomic nervous system (ANS) activity with the index of heart rate variability (HRV) and various forms of meditation. HRV generally reflects vagal activity that indicates the state of the ANS. The ANS is divided into two parts, the parasympathetic nervous system (PNS) associated with resting the body and the sympathetic nervous system (SNS) which is linked to activation of energy resources. When these two systems are well balanced it translates to increased levels of HRV. Thus, higher levels of HRV is thought to indicate the ability for an individual to react and organize context appropriate behaviours to emotions and cognitions. In fact rigid regularity of both the PNS and SNS, measured as low levels of HRV, is associated with mortality, morbidity, and lower physical and psychological health.

Takashi et al. (2005) found that slower and consistent respiration rate during a meditation practice induces

changes in the ANS that corresponds to an increase in HRV. Furthermore, PNS activity as indicated by HRV has been found to increase as a result of focused meditation (Nijjar et al., 2014; Wu & Lo, 2008). Increased HRV was related to decreased chronic stress, depression symptoms and higher levels of anxiety (Davydov, Shapiro, Cook & Goldstein, 2007; Schubert et al., 2009). HRV has also been used as a measure the efficacy of yoga interventions, specifically finding that increases in HRV are related to decreases in stress and anxiety after a yoga intervention (Brown & Gerbarg, 2005; Cheema et al., 2013). Research found HRV activity measured during the observation of stimuli judged pleasant is higher than measurement throughout observations of neutral stimuli (Vecchiato et al., 2011). However, a consensus has yet to be drawn on HRV's use as a biomarker of positive affect and experienced pleasantness in response to mental activity such as meditating, practicing yoga, or responding to positive stimuli. Furthermore, no previous research has compared HRV with virtual reality meditation as a measure of the positive experience it has on a person's physical health.

Breathing practises have been found in previous studies to balance the autonomic nervous system. When exploring further it was found that the balancing of the ANS was tied to positive changes in regions of the brain ranging from cortical, vagal, phrenic and medulla oblongata neural changes. This hints that the balanced functioning of the ANS is crucial for optimal health. Furthermore when the ANS balance shifts in a positive directions as shown by decreases in sympathetic nervous system activity and increased parasympathetic activity. The balancing of the ANS is likely what caused a seemingly positive shift and rebalancing of of glucose levels, heart rate and blood pressure as noted in the current study with the observed health producing effects. Therefore, this intervention returns the body to homeostasis.

Another possible mechanism of the current study's results can be explained by changes at the cellular, bioelectric fields level, due to increased blood flow and oxygenation. We postulate that increased oxygenation and blood flow causes more cellular, quantum resonance, in each haem molecule, on each erythrocyte (red blood cells).

This increased bioelectric field resonance then **also** interacts with the cells receiving the oxygen molecules, thereby making them more *healthy* and *normal*, and may even activate DNA repair enzymes, thus repair these cells.

This can be investigated by spectroscopic studies, which can consider whether indeed there is any increased bioelectric cell to cell communication within the blood stream is occurring between the interalveolar septum, blood cells, and other cells. This interalveolar septum is the region where oxygen gets transported into cells and Co is transported into the lungs. Therefore, changes at these biomembranes with oxygenation could have a positive impact on one's health. (Cramer & Knaff, 1991; Meisenberg & Simmons, 2017).

Previous studies involving virtual reality application to mental health and physical health treatment have found success, this is well summarized in a review by Gregg & TARRIER (2007), it was found that “VR technology potentially provides a means for understanding, assessing and treating a number of clinical disorders. The potential benefits of VR are immense: virtual environments are flexible and programmable and their use fits well within established psychological theory and practice. Patients are generally accepting of the technology and the evidence that people react in virtual environments as if they were real is compelling.” However, the review concluded that most research has lacked the sort of rigour needed to decide if virtual reality applications to mental health treatment have significantly better treatment outcomes than other treatment modalities. This study adds to literature by demonstrating virtual reality's efficacy in treating physical disorders, thereby virtual reality may indeed be the newest evolution of complementary medicine. Past examples of complementary medicine such as yoga and meditation have been effective but have suffered from **high dropout rates among participants and low engagement**. So although they have been shown to be powerful adjuncts to traditional medical treatments, they have not been able to be effective for a majority of patients. Virtual reality may present an excellent new option to increase motivation, participation and engagement in meditation programs through its immersive environments and personalized audio/visual experiences.

The influence of music (improved mood/relaxation)

The participant was given a choice of music to select from day to day, as qualitative analysis revealed that this likely add an impact on her mood state to start the intervention. Music has been shown to modulate our emotions and mood state, this is a powerful tool when applied to relaxation as was found in Krout (2007), where music induced greater relaxation in participants and neurologically demonstrated increased wellness. Music produces an emotional arousal by influencing CNS, ANS, endocrine, limbic and cellular systems, “caused by an interruption of expectancy or anticipation patterns that are based on perceptual-motor schema”. (Juslin & Sloboda, 2012, p. 824)

Previous research on the application of music to modulate mood for relaxation, has found that when a participant is given the choice of music to set the mood, they are able to enter into a more relaxed state more easily (Saarikallio & Erkkilä, 2007). This could be because the listener is able to apply his/her own meaning and emotion to the perception of the musical stimuli (Juslin & Sloboda, 2012). This emphasizes the importance of personalizing music for optimal results during this intervention. As such, future studies should compare when participants are given the choice to set music, not given the choice, no music vs. music and other explorations of the effect of music on treatment outcomes.

Shifts in Consciousness States

Several interesting themes arose from this study. For example, the participant described experiences of higher openness to experience, and mystical states of consciousness, which in previous studies has been associated with increases in absorption and perhaps increased hypnotic ability for those with greater meditation experience (Berkovich-Ohana & Glicksohn, 2016, Glisky et. al., 1991). Berkovich-Ohana & Glicksohn suggested a model of consciousness that shows meditators have differential experiences of time, awareness and emotion. This suggests a shift in consciousness called the consciousness state space (CSS). The CSS predicts that experienced meditators

will experience a reduced sense of narrative self (personal identity, conceptual thought and time distortion) and as a result an increased sense of selflessness. Meditators will also experience greater identification of the phenomenon of experience itself and a reduced sense of timeline, in other words, the present moment resides away from past and future mental time traveling. Meditators will experience heightened awareness, specifically called pre-reflective awareness, direct awareness of experience prior to any reflection of the experience. The final expectation of a meditators shift in CSS is that both negative and positive affect would be reduced and a greater experience of equanimity would occur. (Berkovich-Ohana & Glicksohn, 2016). Future studies should explore the CSS further using our intervention to explore how VR, vowel intonation and specialized breathing may effect the shift in CSS differently from meditations used in the original studies. This is consistent with previous studies by Singh et. al. (2016) demonstrating that VR intervention can quickly enhance altered, higher states of mystical consciousness and improved mood.

The importance of Meaningful Personalization of the Intervention (music and imagery)

In Day 5, the participant made many comments on the increased motivation she felt as a result of the personalization done in the study. This indicates that all future studies should consider the implications and positive effects personalized therapy may bring. In particular when developing interventions that make use of technology it becomes much easier to provide choice to the participant, this is in many ways a winning attribute of VR. The ability to allow the participant to choose the most meaningful (highest valence) positive effects audio-visual environment in which to experience the intervention gives the participant a degree of control that may motivate continued use of the therapy. This solves a major problem of many take home interventions, which often have low adherence to the therapeutic schedule.

Combining treatments

Combined multimodal treatments have become an efficacious way to support the shortcomings of any

single therapeutic intervention, therefore boosting the chances of high-impact on the patient's health. In this study a combination of vowel intonations, specialized breathing techniques and a virtual reality meditation experience was shown to be a useful combination for treating diabetes, a multi-faceted disorders. Each part of the intervention was seemed to impact a different symptom of diabetes. If this is indeed the case, it demonstrates the utility of combining interventions in innovative ways. For example, creating a program that integrates scientifically supported complementary medicine techniques with the newest innovations in technology may unlock treatment interventions with excellent efficacy for difficult to treat disorders for diabetes, this includes a well-balanced diet, rich in (fe) iron because the hemoglobin molecule in each blood cell, which transports oxygen molecules has at its centre the haem (fe), which can engage in **cellular resonance**. Hemoglobin is also impacted by resonance and will oxygenate blood optimally when resonated optimally this seems to match the effects of traditional pharmacological intervention.

Limitations

The current study was done over five days, this limits the findings to short term influences on the participants HRV, blood pressure and blood glucose. This intervention was exploratory and as a result of only having 1 participant did not include a control intervention. This meant that although we were using an innovative intervention, we are not able to tease apart the differences in effects between regular audio guided meditations and virtual reality guided meditation, between intonation practise and listening to sounds, between specialized breathing and vowel intonation practises. Although the participant did indicate that the level of immersion helped her gain a deeper experience, it is not clear if this was caused by the controlled environment or the intervention itself. However, qualitative data indicated that the participant was positive about her experience and physiological data showed a positive increase in heart rate variability. This change is consistent with previous findings in the literature on the impact of meditation practise on HRV, such as in Nesvold et al. (2012). Future study designs

should control for the effects of a guided meditation practise to tease apart the added benefit of virtual reality to increasing the immersion and focus of a guided meditation session. This can be done by having one group undergo a guided meditation through just audio and a second group does the upgrade virtual reality version of the same guided meditation.

Conclusion

The intervention used for this case study was designed to be quick, simple, and effective so that anyone could use at home on their own time with the correct hardware and get positive results. This is the essence of complementary medicine to empower an individual to do more than just take medicine but to also work on their physical and mental wellness in the privacy of their home. For a patient with diabetes this can be especially important as it is often difficult to make an optimal impact on your symptoms through just nutrition, meditation or exercises. One needs a combined intervention that takes into account ease of use and delivery of the intervention. Furthermore, with the excitement of VR we are hopeful that patients would be introduced to meditation, intonation and breathing practises and begin to do it without the need of the hardware, training themselves on how to reach these healthy states on their own eventually.

Our findings indicate new possibilities for exploring individualized and large group treatments that could expand the reaches of how virtual reality technology, specialized breathing, and sound healing is applied in the medical setting. If doctors can recommend people to engage in such “home based”, easy-to-learn-and-use techniques including the breathing and intoning techniques, as well as VR meditation programs, we may be able to decrease some of the stress and cardiovascular symptomatology associated with Type-2 diabetes and create a more healthy population. This is preventative and complementary medicine at its finest. This treatment could also be used by those who are not yet diabetic but at-risk diabetics, as it could be used to prevent or delay the possible early onset of diabetes. Future studies must explore this intervention with large participant pools, control groups

comparing regular meditation to VR meditation, with and without vowel intonations or specialized breathing practises. Furthermore, future studies must explore how varied settings on the personalization components of this program impact treatment outcomes. For example, does allowing the participant to choose their own guided meditation improve their motivation and lead to increased treatment outcomes or does it have no impact? Our hope is that this case study will inspire many new studies in this field and lead to a clear understanding of how vibrational medicine, personalized meaningful virtual reality meditation music, specialized breathing techniques, and vowel sound intonations can be used to improve the outcomes and longer compliance of Type 2 diabetes treatment and health and well-being generally.

References

- Absolon, N., Balneaves, L., Truant, T., Cashman, R., Wong, M., Hamm, J., & Witmans, M. (2016). A Self-Administered Sleep Intervention for Patients With Cancer Experiencing Insomnia. *Clinical Journal of Oncology Nursing*, 20(3), 289-297.
- Ahmad, S. (2013). *Diabetes: An Old Disease, a New Insight*. New York, NY: Springer Science Business Media, LLC.
- American Diabetes Association. (Ed.). (2017, July & aug.). Statistics About Diabetes. Retrieved September 25, 2017, from <http://www.diabetes.org/diabetes-basics/statistics/?referrer=https%3A%2F%2Fwww.google.ca%2F>
- Amita, S., Prabhakar, S., Manoj, I., Harminder, S., & Pavan, T. (2009). Effect of yoga-nidra on blood glucose level in diabetic patients. *Indian Journal Physiology Pharmacology*; 53 (1) : 97–101
- Armony, J., & Vuilleumier, P. (2013). *Cambridge Handbook of Human Affective Neuroscience*. Cambridge: Cambridge University Press.
- Brown R. P. & Gerbarg P. L. (2005). Sudarshan Kriya yogic breathing in the treatment of stress, anxiety, and

depression: part I neurophysiologic model. *J Alternat Complement Med*, 11, 189–201.

- Bunt, L., & Pavlicevic, M. (2001). Music and emotion: Perspectives from music therapy. In P.N. Juslin & J.A. Sloboda (eds), *Music and Emotion: Theory and research* (pp. 181-201). Oxford: Oxford University Press.
- Cheema, B. S., Houridis, A., Busch, L., Raschke-Cheema, V., Melville, G. W., Marshall, P. W...Colagiuri, B. (2013). Effect of an office worksite-based yoga program on heart rate variability: Outcomes of a randomized controlled trial. *BMC Complementary and Alternative Medicine*, 13(1), 82-82. doi:10.1186/1472-6882-13-82
- Cramer, W. A., & Knaff, D. B. (1991). *Energy transduction in biological membranes: a textbook of bioenergetics*. New York: Springer-Verlag.
- Clark, D. M. (1983). On the induction of depressed mood in the laboratory: Evaluation of the Velten and music procedures. *Advances in Behavior Research and Therapy*, 5, 27-49.
- Davydov, D. M., Shapiro, D., Cook, I. A., & Goldstein, I. (2007). Baroreflex mechanisms in major depression. *Progress in Neuropsychopharmacology & Biological Psychiatry*, 31(1), 164-177.
doi:10.1016/j.pnpbp.2006.08.015
- Diabetes Statistics in Canada. (2016, October). Retrieved September 14, 2017, from <http://www.diabetes.ca/how-you-can-help/advocate/why-federal-leadership-is-essential/diabetes-statistics-in-canada>
- Goldman, J., & Goldman, A. (2017). *The humming effect: sound healing for health and happiness*. Rochester, VT: Healing Arts Press.
- Goyal, M., Singh, S., Sibinga, E. M., Gould, N. F., Rowland-Seymour, A., Sharma, R., ... & Ranasinghe, P. D. (2014). Meditation programs for psychological stress and well-being: a systematic review and meta-analysis. *JAMA internal medicine*, 174(3), 357-368.
- Guan, J. (2011). Insulin-Like Growth Factor- 1 (IGF-1) Derived Neuropeptides, a Novel Strategy for the Development of Pharmaceuticals for Managing Ischemic Brain Injury. *CNS neuroscience & therapeutics*,

17(4), 250-255.

- Gregg, L., & Tarrier, N. (2007). Virtual reality in mental health. *Social psychiatry and psychiatric epidemiology*, 42(5), 343-354.
- Hur, S., Han G-S., Cho B-J., (2014). Changes in Glucose, TNF- α and IL-6 Blood Levels in Middle-aged Women Associated with Aerobic Exercise and Meditation Training. *Journal of Physical Therapy Science*. 26(12):1933-1936. doi:10.1589/jpts.26.1933.
- Innes, K. E., & Vincent, H. K. (2007). The influence of yoga-based programs on risk profiles in adults with type 2 diabetes mellitus: a systematic review. *Evidence-Based Complementary and Alternative Medicine*, 4(4), 469-486.
- Juslin, P. N., & Sloboda, J. A. (2012). *Handbook of music and emotion: theory, research, applications*. Oxford: Oxford University Press.
- Kalyani B.G., Venkatasubramanian G., Arasappa R., Rao N.P., Kalmady S.V., Behere R.V., Rao H., Vasudev M.K., Gangadhar B.N., (2011). Neurohemodynamic correlates of 'OM' chanting: A pilot functional magnetic resonance imaging study. *International Journal Yoga*. 4(1):3-6. doi: 10.4103/0973-6131.78171.
- Krout, R. E. (2007). Music listening to facilitate relaxation and promote wellness: Integrated aspects of our neurophysiological responses to music. *The arts in Psychotherapy*, 34(2), 134-141.
- Levine, M. E., Suarez, J. A., Brandhorst, S., Balasubramanian, P., Cheng, C. W., Madia, F., ... & Passarino, G. (2014). Low protein intake is associated with a major reduction in IGF-1, cancer, and overall mortality in the 65 and younger but not older population. *Cell metabolism*, 19(3), 407-417.
- Lim, H., Park, J., Choi, Y., Huh, K., & Kim, W. (2009). Individualized diabetes nutrition education improves compliance with diet prescription. *Nutrition Research and Practice*, 3(4), 315-322.

doi:10.4162/nrp.2009.3.4.315

- Maples-Keller, J. L., Yasinski, C., Manjin, N., & Rothbaum, B. O. (2017). Virtual Reality-Enhanced Extinction of Phobias and Post-Traumatic Stress. *Neurotherapeutics*, 1-10.
- Massion, A., Teas, J., Hebert, J., Wertheimer, M., & Kabat-Zinn, J. (1995). Meditation, melatonin and breast/prostate cancer: Hypothesis and preliminary data. *Medical Hypotheses*, 44(1), 39-46.
- Meisenberg, G., & Simmons, William H. (Medical scientist). (2017). *Principles of medical biochemistry* (Fourth ed.). Philadelphia, Pennsylvania: Elsevier.
- Nava, E., Noll, G. & Lüscher, T., (1995). Nitric Oxide in Cardiovascular Diseases. *Annals of Medicine*. 27 (3).
- Nesvold, A., Fagerland, M. W., Davanger, S., Ellingsen, Ø., Solberg, E. E., Holen, A., . . . Atar, D. (2012). Increased heart rate variability during nondirective meditation. *European Journal of Preventive Cardiology*, 19(4), 773-780. doi:10.1177/1741826711414625
- Nijjar, P., Puppala, V., Dickinson, O., Duval, S., Duprez, D., Kreitzer, M. & Benditt, D. (2014). Modulation of the autonomic nervous system assessed through heart rate variability by a mindfulness based stress reduction program. *International Journal of Cardiology*, 177(2), 557-559.
- Newberg, A. B., & Waldman, M. R. (2010). *How god changes your brain: Breakthrough findings from a leading neuroscientist* (Ballantine Books trade paperback ed.). New York: Ballantine Books Trade Paperbacks.
- Percentage of population with self-reported diabetes. (2017, March 06). Retrieved September 14, 2017, from <https://uwaterloo.ca/canadian-index-wellbeing/what-we-do/domains-and-indicators/percentage-population-self-reported-diabetes>
- Pramanik T., Pudasaini B., Prajapati R., (2010). Immediate effect of a slow pace breathing exercise Bhramari pranayama on blood pressure and heart rate. *Nepal Med Coll J*. 12(3):154-7.
- Rainforth, M. V., Schneider, R. H., Nidich, S. I., Gaylord-King, C., Salerno, J. W., & Anderson, J. W. (2007).

Stress reduction programs in patients with elevated blood pressure: a systematic review and meta-analysis.

Current hypertension reports, 9(6), 520-528.

Reger, G. M., Holloway, K. M., Candy, C., Rothbaum, B. O., Difede, J., Rizzo, A. A., & Gahm, G. A. (2011).

Effectiveness of virtual reality exposure therapy for active duty soldiers in a military mental health clinic.

Journal of traumatic stress, 24(1), 93-96.

Robb, S. L. (1996). Techniques in song writing: Restoring emotional and physical well-being in adolescents who

have been traumatically injured. *Music Therapy Perspectives*, 14, 30-37.

Rossi, E. L. (1993). *The psychobiology of mind-body healing: New concepts of therapeutic hypnosis*. WW Norton

& Company.

Salas-Salvadó, J., Bulló, M., Babio, N., Martínez-González, M. Á., Ibarrola-Jurado, N., Basora, J., ... & Ruiz-

Gutiérrez, V. (2011). Reduction in the incidence of type 2 diabetes with the Mediterranean diet. *Diabetes care*,

34(1), 14-19.

Saarikallio, S., & Erkkilä, J. (2007). The role of music in adolescents' mood regulation. *Psychology of music*, 35(1),

88-109.

Sanada, K., Díez, M. A., Valero, M. S., Pérez-Yus, M. C., Demarzo, M. M., Montero-Marín, J., ... & García-

Campayo, J. (2017). Effects of mindfulness-based interventions on biomarkers in healthy and cancer

populations: a systematic review. *BMC complementary and alternative medicine*, 17(1), 125.

Schubert, C., Lambertz, M., Nelesen, R. A., Bardwell, W., Choi, J. & Dimsdale, J. E. (2009). Effects of stress on

heart rate complexity—A comparison between short-term and chronic stress. *Biological Psychology*, 80(3),

325-332. doi:10.1016/j.biopsycho.2008.11.005

Signs & Symptoms. (n.d.). Retrieved September 14, 2017, from <http://www.diabetes.ca/about-diabetes/signs-and-symptoms>

symptoms

- Singh, R. N. (1997). *Self-healing: powerful techniques*. London, Ont.: *Health Psychology Associates*.
- Singh, R., Rayo, P., & Singh, N. (2016). The Use of Virtual Reality as a Meditative Neurotechnology. *The Rose Croix Journal, 11*, 83-129.
- Sloboda, J. A. (2012). *Handbook of music and emotion: theory, research, applications*. Oxford: Oxford University Press.
- Stein, P. K., Barzilay, J. I., Chaves, P. H., Traber, J., Domitrovich, P. P., Heckbert, S. R., & Gottdiener, J. S. (2008). Higher levels of inflammation factors and greater insulin resistance are independently associated with higher heart rate and lower heart rate variability in normoglycemic older individuals: the Cardiovascular Health Study. *Journal of the American Geriatrics Society, 56*(2), 315-321.
- The Editors of Encyclopædia Britannica. (2017, May 31). Diabetes mellitus. Retrieved September 14, 2017, from <https://www.britannica.com/science/diabetes-mellitus>
- Vecchiato, G., Toppi, J., Astolfi, L., Vico Fallani, F., Cincotti, F., Mattia, D., . . . Babiloni, F. (2011). Spectral EEG frontal asymmetries correlate with the experienced pleasantness of TV commercial advertisements. *Medical & Biological Engineering & Computing, 49*(5), 579-583. doi:10.1007/s11517-011-0747-x
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology, 54*(6), 1063.
- Weitzberg, E., & Lundberg, J. O. (2002). Humming greatly increases nasal nitric oxide. *American journal of respiratory and critical care medicine, 166*(2), 144-145.
- Wu, S. D., & Lo, P. C. (2008). Inward-attention meditation increases parasympathetic activity: a study based on heart rate variability. *Biomedical Research, 29*(5), 245-250. doi:10.2220/biomedres.29.245

Appendix A

Day 1

The participant felt that the experience overall today was “interesting” and “calming”. By the end of the experience she was yawning and feeling sleepy. This could have been because she was quite tired from the beginning of the day as she told us she did not sleep well the night before. Though she affirms that the experience was not boring, she expressed that she would have liked more movement and interaction with the VR guided meditation. From what she has heard in the past about VR she was expecting a guided story taking her to a place of inner calm... “I would have liked to see, like I said, not necessarily like a movie, but I thought there was more of a story into a calm state... you could be talking about, not necessarily Christ, but they could show you flowers and then gradually going into a different space, you know seeing some beautiful trees and then going and seeing some rocks and what not and then seeing trickling water or waterfall so you’re not bored staying in one spot.”

She did not completely resonate with the guided meditation today. The VR guided mediation was “very fine” but she is adamant about the benefits of personalizing the experience. She recognizes that what she likes is her own personal preference and that the experience should be personalized to the particular person’s inclination and followed faith/beliefs... “it’s supposed to put you at peace, and it would be nice how Muslims have a mosque to resonate with, Hindus with a temple, Christians with their church; where someone goes to make peace with their maker so to speak... that’s what I see.”

She found the breathing techniques to be challenging. It was difficult for her to form the visualizations while also trying to focus on the breath. She also expressed she did not like the woman’s voice that was guiding the breathing. The intonations, however, she found to be “fine” and “calming”.

When she considered her overall experience today, she preferred the VR to the intonations, “the water and stuff put you at peace, for me.” She described her overall view of the day as, “very nice”.

Some considerations that could have affected the participant’s experience was her unfamiliarity with the

tools used today. She expressed frustration with the chosen adjectives in the mood questionnaire as she did not feel they were useful in describing the state of her disposition. She also showed frustration with the VR system when not knowing how to use it initially. It would be more effective in the future to have participants go through a short tutorial with the technology before the study so that they feel more comfortable and at ease when using the devices before beginning.

Day 2

The second day for the participant was more enjoyable for her compared to the first day. She felt that today's experience was "fabulous" which was influenced greatly by the background music in the room. She expressed that the music influenced the rest of her experience today; it was flowing and put her at peace. When asked what stood out to her today she responded, "in general what really stood out to me was to come in here and hear the soft music in the background playing... the music was enough to put you in the mood. You see the trees and you see the wind, you're hearing it rustling." This shows the power that background music has in setting the emotions and intentions of the participant.

The breathing exercise she felt was challenging again today and does not care for it. She expressed a lot of frustration with trying to follow the guided visualizations, "I am forcing myself to try and see the visualizations and it still baffles me and I cannot do it, and I'm trying for the life of me to visualize the blue light and it's impossible... I can't do that piece I'm trying but I can't."

She admitted to us that yesterday she felt uncomfortable, frustrated, and even stupid because she did not understand how to use the VR equipment. That was a significant difference in her experience compared to today. Today she feels better and that she understands how to use the technology. Having participants come in before the study to learn how to use the VR could alleviate these potential frustrations in the future so as to not affect our findings.

The VR guided meditation was “very fine today” and she liked it more than yesterday. She felt her disposition today after the whole experience was much different than yesterday’s, “I was peaceful, I was calm, I feel energetic. It can put you in a totally different frame of mind to carry out your day.” As opposed to yesterday, she does not feel sleepy at all. Overall, she seemed much more comfortable and positive about the experience on her second day which could likely be due to her feeling more familiar with the process this time.

Day 3

Today the participant seems more energized and upbeat. She was very happy with her experience today, she felt the background music was “superb, beautiful and very uplifting” and really took her into a place of deep calm, “the music today could really take you deep... you don’t have to think about anything else. I pictured myself going to the altar, you know, to see God.”

She enjoyed most of the aspects of the VR meditation today and emphasized that the perspective was very nice and that she enjoyed hearing the birds chirping inside the meditation. However, she did not enjoy the mantra in the VR meditation, “I want to make my life better”. She felt it was too repetitive. Overall, she felt peaceful and calm as usual.

She thought that the intonations would be different today but expects that there is a good reason for the ones chosen, perhaps geared towards diabetics. Because of this she does not feel intonations are getting repetitive because she feels they are working toward something positive. She seems to be thinking deeply about the different aspects of the study and feels that each intervention is purposeful.

Today there is a major shift in the participant in terms of her openness with her emotions. She is sharing more about her personal life, of some of the struggles and events that have deeply troubled her. This could likely be a result the interventions these past few days in putting her in a state of greater awareness and reflectiveness in combination with feeling more comfortable in this space and with the interviewers. Her openness and reflectiveness

today suggests that the interventions over the past three days are the cause by putting her in a calm and compassionate state.

Day 4

Today's experience for the participant was "fabulous – soothing and peaceful" and the music was "beautiful". She feels that today was much shorter than the previous days, as though she just arrived. This is a positive reflection and suggests that she is calm, at ease, and enjoying her experience. This was reiterated when she told us that today's meditation and overall experience was her favourite so far. The meditation felt more personalized for her as she loves temples and ancient settings. The scenery in this meditation reminded her of her time in Pompeii. The participant really enjoys VR experiences that feel familiar and remind her of a real life experience she has had in her past. This demonstrates the importance of personalizing VR experiences, as different people will resonate with different sceneries differently according to their past experiences.

After the intervention she was eager to open up about her life growing up as well as her current stresses and troubles. She reflected for a long while on Christmas time, loving details about her father, and different stories of her family. She also opened up about her stresses in her daily life such as feeling quite rushed in her day. The calming setting and VR experience have seemed to provide the participant with an ideal atmosphere to open up about her feelings and emotions.

Day 5

Today the participant felt the VR experience was very energizing. Watching the waves inside the VR meditation made her mind a little more active. She enjoyed watching the movement of the water and expressed that she did not want to come out. She felt that the mantra of the meditation, a reminder to take care of one's self, really spoke to her, "that is so important for me, so it sort of resonated that way, in terms of a reminder that you have to look after you and take care of you... so it was nice." Today she felt as though the experience was completely

personalized to her and the whole intervention resonated with her more so than the other days. She felt we did a better job today focussing on her likes. She had mentioned that she loves piano music and loved the background piano piece we had chosen. She expressed that the last two days were really phenomenal experiences and ranked yesterday (Thursday) as her favourite. She felt that the hour intervention yesterday felt

like 5 minutes and today felt like 15 minutes, which suggests that she is enjoying her experience and is feeling relaxed.

She still finds the breathing exercise challenging because she cannot hold her breath for very long. Although the intonations do not resonate with her in the moment, she is beginning to feel their effects later in the day as enabling her to deal with stressful situations more calmly, “I’m doing it, but I am not feeling anything out of it. But now I’m thinking when I’m driving and stuff like that, to put me in a calmer state, I could literally say those vowel sounds on my own...” The intonations provide explanation on what areas of the body that particular vowel sound is helping, which she finds to be effective.

Today, her disposition is quite jovial, just as yesterday. She seems eager to talk and tell us about her family and was happy and laughing while reminiscing on time spent with her daughter.