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Viability of Physiologically Timed Relaxation Interventions in Children with ASD

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Viability of Physiologically Timed Relaxation Interventions in Children with ASD

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by

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Abstract

Autism Spectrum Disorder (ASD) is an increasingly common developmental disorder that changes how people experience the world and affects individuals' social interactions and often leads to many adverse behaviors. Current literature dictates that a primary contributor to these adverse behaviors is that those with ASD have difficulty determining their own emotional states and determining the physiological signals that their body sends them. A study by Dr. Sarabadani et al. determined that it was possible to monitor the physiology of an individual with ASD and correlate certain signals to emotions, such as stress. These findings indicate the feasibility of establishing a physiologically based approach to emotion recognition and could entail a technological solution to the problems that individuals with autism face. It is the goal of this project to determine the efficacy of utilizing a physiological approach to minimize the impact of the adverse behaviors through the implementation of relaxation techniques at key points when stress levels are rising. If the interventions are successful, we would expect to see a decrease in the amount of reported emotional outbursts which would be reflected by fewer spikes in the measured physiological responses. If the interventions are not successful, we would see little impact on the amount of outbursts and the number would remain relatively similar to before the study.

Introduction

Autism Spectrum Disorder (ASD) is an increasingly common developmental disorder that changes how people experience the world and affects individuals' social interactions. Roughly 2 percent of the United States population has been clinically diagnosed with ASD and these individuals commonly experience unique social interaction behaviors, such as problems with eye contact and struggling to hold a conversation. Individuals with ASD also tend to display restrictive or repetitive behaviors, such as a strong reliance on routine or being more, or less, sensitive than other people to sensory input, such as light, noise, clothing, or temperature. These hinderances in everyday life often lead to stunted social growth and adverse behaviors such as outbursts of emotion caused by the increased stresses of their everyday lives.

Current literature dictates that a primary contributor to these adverse behaviors is that those with ASD have difficulty determining their own emotional states as well as the emotional states of those around them (Baron-Cohen et al. 1994). One explanation for this disconnect has been provided by Lambie and Marcel, who have characterized the emotional experience in a two-level model (Lambie and Marcel 2002). The first is neurophysiological arousal in the amygdala-orbitofrontal system and second is an awareness of the emotion. It has been found that individuals with ASD do not generally exhibit a diminished response in the brain regions dealing with emotion, but rather the issue lies in recognizing their emotions. This indicates that there is a disparity between the perception of an emotion and the resulting anatomical response that it produces (Silani et al., 2008). This can be frustrating for an individual, not being able to interpret your bodies signals and not understanding why you feel the way that you do. In the case of people with ASD, this is particularly important when considering stress and the implications of being unable to identify stress factors and properly handle them. Being unable to recognize that your body is sending you stress signals but still reacting to them is confusing and may cause some of the adverse behaviors that individuals with ASD experience.

When a typical individual is presented with a stimulus, such as stress, their autonomic nervous system (ANS) initiates a physiological response to react to the conditions of the environment. The ANS is broken up into two branches. The first is the sympathetic nervous system which handles responding to threats, or “fight or flight” scenarios with initiating processes like increasing heart rate and respiration. The other is the parasympathetic nervous system, that handles the “rest and digest” processes of the body. “Digest” functions include increasing salivation or enacting the movement of the stomach or intestines. “Rest” functions are accomplished by utilizing the vagus nerve to initiate cardiac relaxation by reducing contractility in the heart muscles, resulting in a lowered heart rate. This process is essential to recovery from the states of arousal induced by the sympathetic nervous system (Waxenbaum et al. 2021). The two systems are intertwined and work together to ensure the body correctly responds to the given situation. If either nervous system is not functioning as intended, an individual may react improperly to their environment or even an uncomfortable social situation.

It has been found that youth with ASD appear to demonstrate a blunted parasympathetic response when compared to typical individuals. This manifests as an inability for the body to return back to baseline from an excited state whether from positive or negative stimulus (Muscatello et al. 2021). In the case of social interactions, this can entail an increase in anxiety during and following an interaction without an effective way for their body to return to a relaxed state. This prolonged state of excitation indicates that individuals with ASD may be more adversely affected by and susceptible to stress factors when compared to their typically developing counterparts. Coupled with a difficulty in recognizing these bodily responses and the emotion it is associated with, individuals with ASD are at a distinct disadvantage when put out of their comfort zone. For example, if a student with Autism is struggling with a homework assignment, their bodies may begin showing physiological signs of stress whether increased heart rate, respiratory rate, or even skin temperature. These signs may go unnoticed and with a blunted parasympathetic response, these symptoms can persist long after they are done working on the assignment. The prolonged physiological strain may culminate in an adverse behavior such as an emotional outburst or instance of self-harm.

Through therapeutic programs and treatment plans, individuals with autism are often taught behavioral management techniques to be used in the day to day to try and bolster their parasympathetic system and reduce the effects of stress. Behavioral therapy for individuals with autism is often based on applied behavior analysis (ABA). The most common ABA treatment plans are Positive Behavior and Support, Pivotal Response Training, Early Intensive Behavioral, Intervention, and Discrete Trail Teaching ("Behavioral Management Therapy for Autism" 2017). Each treatment type has a slightly different focus, but they have the common theme of reinforcing wanted behaviors and reducing unwanted behaviors. This is typically accomplished through a positive or negative feedback loop, where the individual is rewarded or not for engaging in desired behavior. In doing so, therapists can often be met with the aforementioned outbursts and problem behaviors. These behaviors often halt the progress being made as the therapists must stop their instruction to return the individual to a relaxed state by utilizing a variety of techniques ranging from distraction methods, deep breathing, or meditation (Sequeira and Ahmed 2012). These techniques are useful if a therapist is present and able to identify if stress levels are beginning to rise. However, due to the disconnect between and individual with ASD and their interpretation of these signs, it may be difficult for the therapists to recognize them as well and the problem still lies with identifying these signals.

In a study by Sarabadani et al, the researchers investigated the viability of differentiating the physiological activity of affective states in children with ASD using physiological signals (Sarabadani et al. 2020). This was accomplished by examining the effects of stimuli on four physiological signals: electrocardiogram, skin conductance, respiration, and skin temperature. By utilizing relatively unobtrusive means, it was found that there are discernible patterns within these metrics that can identify different affective states of arousal (high/positive, high/negative, low/positive, low/negative). These affective states and the physiological measurements associated with them can be correlated to various emotions. Previous studies in typically developing individuals have shown that changes in electrocardiogram, temperature, and skin conductance readings correspond with sadness, anger, and stress with roughly 78% accuracy (Andreassi 2010). These findings indicate the feasibility of establishing a physiologically based approach to emotion recognition and could entail a technological solution to the problems that individuals with autism face. By giving them a means of emotion identification, the behavioral management that are taught in therapeutic programs can be utilized to their greatest extent, especially those dealing with stress reduction.

It is the goal of this project to determine the efficacy of utilizing a physiological approach to minimize the impact of adverse behaviors of individuals with ASD through the implementation of relaxation techniques at key points when stress levels are rising. In order to accomplish this, it is important to understand the effects of stress stimuli on the body of individuals with ASD. This project hopes to test the therapeutic viability of applying the concepts of monitoring physiological signals in a similar fashion to Sarabadani et al. This study would entail observing a group of individuals with ASD as they undergo standard clinical therapy. Before the observation period begins, each individual would have baseline measurements taken of the selected metrics, electrocardiogram and skin temperature. This would give their therapists a general idea of how their body responds to various stimulus and allow them to set patient-specific thresholds to determine when the individual is beginning to experience the symptoms of stress. During the observation period, whenever these physiological signals begin to rise, the therapists would intervene with a relaxation technique, progressive muscle relaxation or breathing exercises, and record the effectiveness of the intervention. These ratings along with the continuous physiological measurements being taken will allow us to determine the effectiveness of the relaxation techniques. If the interventions are successful, we would expect to see a decrease in the amount of reported emotional outbursts which would be reflected by fewer spikes in the measured physiological responses. If the interventions are not successful, we would see little impact on the amount of outbursts and the number would remain relatively similar to before the study.

Methods

Overall Study Design

This study will consist of 3 major components. The first is a weeklong habituation period, during which, the subject group will be given designated wearable devices in order to habituate to them and reduce any affect that they may on have behavior or physiological signals during the experimental period. No measurements or data will be taken for the duration of this period and no relaxation interventions will be implemented; therapy sessions will continue as before the project began and the individuals will simply become used to wearing their watch. The second component is a round of baseline testing to determine how the physiology of each member of the subject group responds to different stimuli and emotions and establishing the baseline and threshold values for the individuals. Next comes the control period, where the participants will be wearing their devices, but no relaxation techniques will be implemented during their therapy sessions. The data from this period will serve as a reference point for the two experimental treatments that will serve as the final component of the study.

The experimental period will consist of two different treatments. The first is a period that will include physiologically-timed relaxation interventions that will utilize data from the baseline testing in conjunction with relaxation intervention at key points where stress levels are beginning to rise. If the interventions are effective, we should see a decrease in the number of outburst and hopefully and increase in therapy session quality. The other period will involve randomly-timed interventions and will serve as an additional reference in determining the effectiveness of the physiologically timed techniques. If the changes in outbursts and session quality are not significantly different between the two experimental treatments. It would indicate that the timing of the interventions is not as impactful as simply having the interventions at all is more significant.

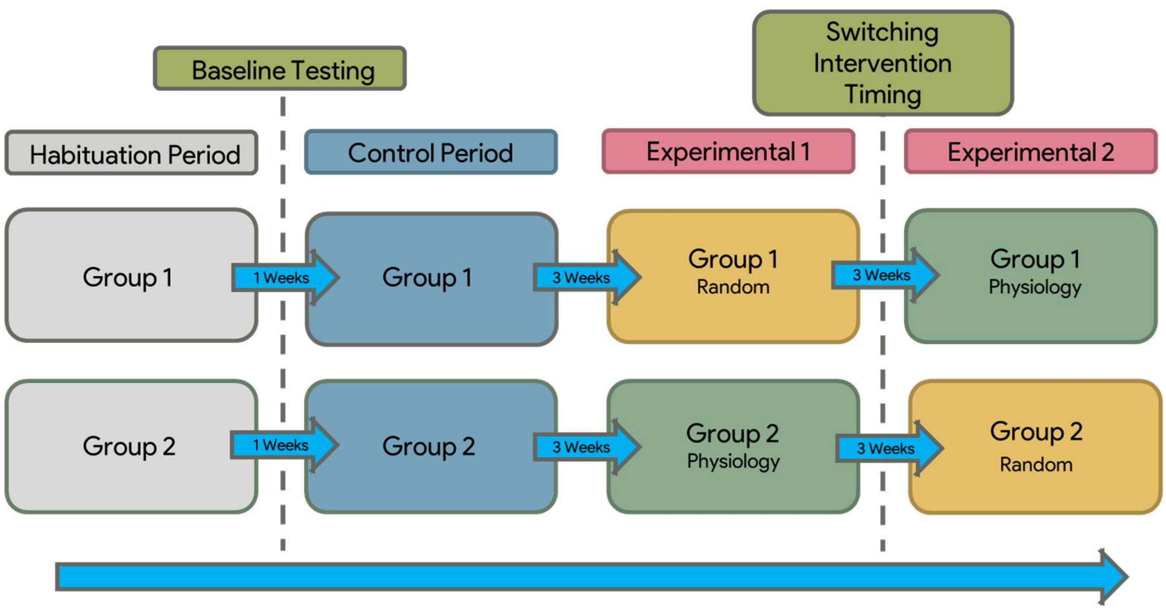

Figure 1. Timeline for the study design of the experiment. In total the study would take about 7 weeks with the participants undergoing various treatments for each period.

Participants

This study would ideally consist of around 15 individuals with ASD that are between the ages of 8 to 12 years old with diagnoses that would be classified as moderate. This specific subject group will likely be the most receptive to the relaxation interventions and will give us the best chance at determining if there is a difference between the control and experimental periods in our study. The model subject group for this project is the Claremont Autism Center a clinic located at Claremont McKenna College, which consists of 12 males and 9 females ranging from 5 to 18 years old. The center is a behavior modification treatment and research program for clinically diagnosed autistic children and their families. Each child is assigned a therapist and has their own individually designed treatment program. This type of system would be ideal for this project due to the extent the symptoms of autism and can vary from person to person as well as how much their physiological responses can vary. Individual treatment plans and specific therapists will ensure that as many controllable variables as possible remain constant.

Monitoring Technology

Monitoring physiological stress is an important way to mitigate the negative impacts of psychological stress on an individual. Consequently, various technologies have been invented in order to assist in the monitoring in real time through measuring metrics such as skin temperature, skin conductance, heart rate, etc. (Yoon et al. 2016). Since the 2016 study by Yoon, et al. physiological monitoring technology has become much more advanced and more importantly, widely available. The device chosen for this project is the "Fitbit Sense," a smartwatch created by Fitbit that has been geared toward health by providing tools for stress management and heart health. This particular wearable was chosen over the other options because of the unobtrusive nature of the watch and the ease of utilizing and recording the data from the physiological sensors on the device. In the study by Sarabaani et al., participants had to wear an array of leads, electrodes, belts, and thermistors from all around the torso, down to the fingers, that was all fed wired to a computer and recorded using the Procomp Infiniti system (Though Technology Ltd.) in order to obtain their data. This multitude of wired attachments may have been effective for the stationary clinical study conducted by that team but would not be practical in a study attempting to emulate real-life situation such as this project. In contrast to the hardware used in the study by Sarabadani et al. the "Fitbit Sense" functions wirelessly over Bluetooth and takes all readings from a single location on the participant's wrist. This method of monitoring would be much less likely to distract or disturb the participants as they go about their typical therapeutic routine while allowing for data to be obtained.

In addition to the physical benefits of utilizing a smart watch over the typically used array of sensors, the Fitbit phone application has already done much of the leg work for compiling and interpreting the physiological data that it receives from the device. All sensor readings are compiled in the Fitbit Phone application for easy access and use of any pertinent data. Some useful pre-programmed features of the application are and electrocardiogram (ECG), PurePulse® Heart Rate Tracking, and a Skin Temperature sensor. Baseline measurements and threshold values can be inputted into the application for these metrics, meaning researchers can easily monitor these physiological signs and can even be notified if they elevate above the set thresholds. This feature is pivotal to the study design, since it allows the therapists to be alerted when stress levels in the participant begin to rise and can implement the relaxation intervention in attempt to reduce an outburst or adverse behavior from occurring.

Habituation Period

The 1-week habituation period begins with administering the Fitbit to each of the children in the study group with the goal to normalize the use of the smartwatches and habituate the participants to wearing them on a regular basis during therapy sessions. This process is based on the principle of habituation, where an organism's behavioral response to a repeated stimulus, in this case the Fitbit, lessens over time (Rankin et al. 2009). Becoming habituated to the watches will mitigate any affects that they may have on the readings taken during the baseline testing as well as the experimental period. The children will otherwise receive the same treatment that they would otherwise during this week-long period before moving on to the baseline testing.

Baseline Testing

The variability in the symptoms and effects of Autism Spectrum Disorders make it difficult to utilize a generalized set of physiological measurement values to quantify different emotional states. However, prior research has demonstrated that it is possible to detect measurable changes on an individual basis and findings suggest that the efficacy of treatment outcomes would be positively impacted by using subject-specific physiological classification of emotion, rather than focusing on mean changes in the testing group (Sarabadani et al. 2020). In creating a subject-specific plan, it is essential to compare treatment outcomes to a baseline set of measurements.

Prior research dictates that the International Affective Picture System (IAPS) is the benchmark method of unobtrusively eliciting physiological responses (Haag et al. 2004)(Rigas et al. 2007). This system contains an extensive database of 956 images when shown to individuals approximate the physiological response that the individual would have when they experience a particular class of emotion. The researching team would utilize the IAPS to begin building each patient's profile that would be utilized as a general baseline, detailing their body's typical physiological response when experience various emotions.

To determine if the relaxation intervention have a measurable effect on treatment outcomes, this patient profile will be cross-referenced with real time physiological data obtained from wearable devices to hopefully improve the quality of therapeutic sessions. With this information therapists can be notified of what types of physiological responses their patient is experiencing during a session, the emotions associated with them, and utilize this information in their treatment plans. In this study, this real time information will be utilized to implement intervention protocols, in the form of relaxation techniques, as the physiological signs of stress begin to rise in the individual.

Control Period

After habituation has occurred, and the patient profile has been created, the participants will undergo a 3-week period of testing geared toward creating a control set of data to compare the experimental treatments to. During this time, the participants' physiological signs will be monitored but no relaxation interventions will be put into place. However, data will be collected, detailing on average how many outbursts of adverse behaviors occur in a given therapeutic session and the overall session quality. To record this data, each individual and their therapists will be recorded for the entirety of the session. After watching the video, a researcher will give the count of the number of outbursts that occur each session as well as the overall session quality. After the control period has finished, the data will be compiled as a set of averages for each individual participant: mean number of outbursts, mean session quality. After implementing the relaxation techniques in the experimental period, we expect to see a decrease in these values for each individual when comparing the means between the treatments.

Relaxation Techniques

Relaxation techniques that are commonly used in clinical and health psychology are Progressive Muscle Relaxation (PMR) and Slow-Paced Breathing (Matsumoto and Smith 2001). PMR was developed by physician, psychiatrist, and psychologists Edmund Jacobson (Jacobson 1964) has been found to reduce stress and bodily tension, as well as regulating physiological processes (Carlson et al. 1988). There have been many adaptations to the procedure over the years to fit the various study models, but in general the subject tenses a muscle groups for a specified amount of time before relaxing the group and moving on to the next. The order of muscle groups and the time under tension vary between studies but all adaptations PMR are aimed at accomplishing the same goal or reducing physiological stress. Slow-Paced Breathing is another method of stress reduction that has been found to have alleviating effects on the both the subjective and physiological aspects of stress in both children (Uratani et al. 2014) as well as adults (Wells et al. 2012). This method functions by voluntary slowing down an individual's respiratory rate to roughly 6 cycles per minute. Typically, most people breath at a rate between

12 and 20 cycles per minute. By regulating both inhalation and exhalation, the individual can achieve this slower pace and reap the benefits of increasing stress management and cognitive performance under stress (Laborde et al. 2017).

When considering which of these techniques would be best suited for this project, the participant group was heavily considered in the decision making. It was determined that the longer and more complex procedure of Progressive Muscle Relaxation may present a challenge for children with ASD due to their shortened attention span and decreased motor skills. Slow-Paced Breathing offers a much simpler alternative that will likely be easier to integrate into preexisting treatment plans.

Experimental Period

In the experimental period, the protocols for recording data will remain unchanged. The children will still attend their typical therapy session, and researchers will still record the number of outbursts as well as perceived session quality after reviewing the video footage of each session. However during this time, the Slow-Paced breathing relaxation intervention will be implemented. Using the real-time data recording and notification features of the "Fitbit Sense," the therapists will be alerted when their patient is beginning to experience the physiological symptoms of stress. Upon being alerted, they will implement the Slow-Paced Breathing technique for a minimum time of 1 minute to aid the parasympathetic nervous system in returning the physiological readings back to baseline levels. This experimental period will last 3-weeks to determine the effectiveness of the intervention methods.

To further determine if the physiological timing is the key factor in reducing stress levels and increasing treatment outcomes, there will be an additional experimental period. During this 3-week period, the therapists will receive randomly timed notifications throughout the session to begin implementing the Slow-Paced breathing interventions. These signals will not be based on the physiological signals or readings from the Fitbit but the same protocols will be implemented as if they were physiologically based. Comparing these two experimental treatments with the control period will allow us to determine what is causing the changes in outbursts and session quality that we expect to see.

Analysis

Data Collection

Aiding the children's blunted parasympathetic response with targeted interventions of breathing techniques should help them return to a calmed state and manifest in an increase overall session quality. Thus, we expect to see better treatment outcomes for each individual during the physiologically timed experimental period and a reduction in the number of emotional outbursts. The metric of number of outbursts will be taken as a count of all of the total amount of outbursts of adverse behaviors each day and will be recorded by an observer of the session recordings. ANOVA will be used to determine if the change in the number of outbursts varied significantly for each individual between the 3 periods: control, random timed interventions, and physiologically timed interventions.

As a secondary result, we also hope to see a statistically significant increase in the reported session quality. The metric of session quality will be taken once the observer has finished watching the recording of the therapy sessions. The researcher will be presented a Likert scale with response options of Positive, Slightly Positive, Neutral, Slightly Negative and Negative and will make their choice based on the therapeutic goals of the individual. For example, in young children with autism, it is common to have predetermined objectives to measure the progress of the therapy sessions, such as talking in complete sentences or using adjectives to better express their thoughts. A session will be scored Positive if a majority of these objectives have been met and Negative if they have not. Since this data is categorical, a chi-square test of significance will be utilized to determine if there are any differences in the overall session quality between the 3 periods.

Potential Results

We predict that the physiologically timed aspect of the relaxation interventions will be pivotal in achieving the best outcomes and will culminate in greater changes in number of outbursts and session qualtiy when compared to the randomly timed period. If our prediction is correct, we should see a significant decrease in the mean number of outbursts for each individual when comparing the experimental treatments to the control. Furthermore, this decrease between the physiologically timed treatment and the control period should be larger than the decrease for the randomly timed treatments.

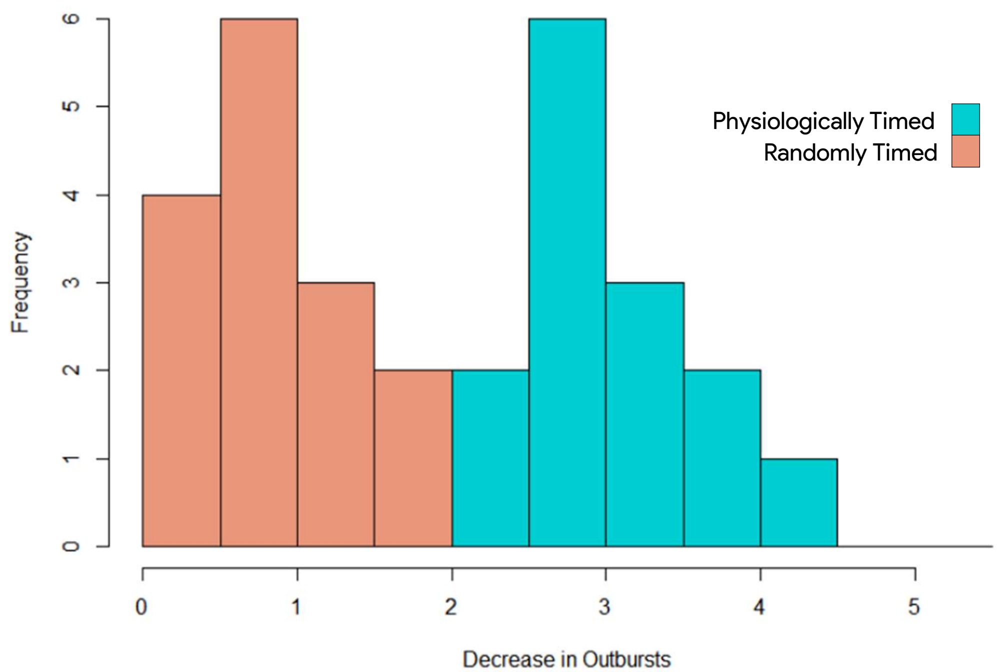

Figure 2. Hypothetical histogram of the decrease in mean outbursts when comparing Physiologically Timed and Randomly Timed relaxation interventions to the control period. This randomly generated data demonstrates a significant decrease in outbursts for both experimental treatments with the largest decrease with physiologically timed interventions.

We would also expect to see similar trends to those shown in Figure 2 when comparing the changes in mean session quality for the individuals between the 3 treatment groups. The greatest differnce should occur when comparing the physiologically timed averages to the control, where we would observe and increase in session quality. If the prediction that the timing of the interventions is the critical factor for this method of treatment, we would expect to see larger increases in session quality during the physiologically timed treatment than the randomly timed treatment.

If our prediction that physiologically timed intervention methods will yield the best outcomes is incorrect, there are a few possible scenarios. The first is that the number of outbursts and session quality between the 3 treatments would not differ and we cannot reject the null hypothesis. This would indicate that the Slow-Paced breathing technique is not an effective way of mitigating stress in individuals with ASD.

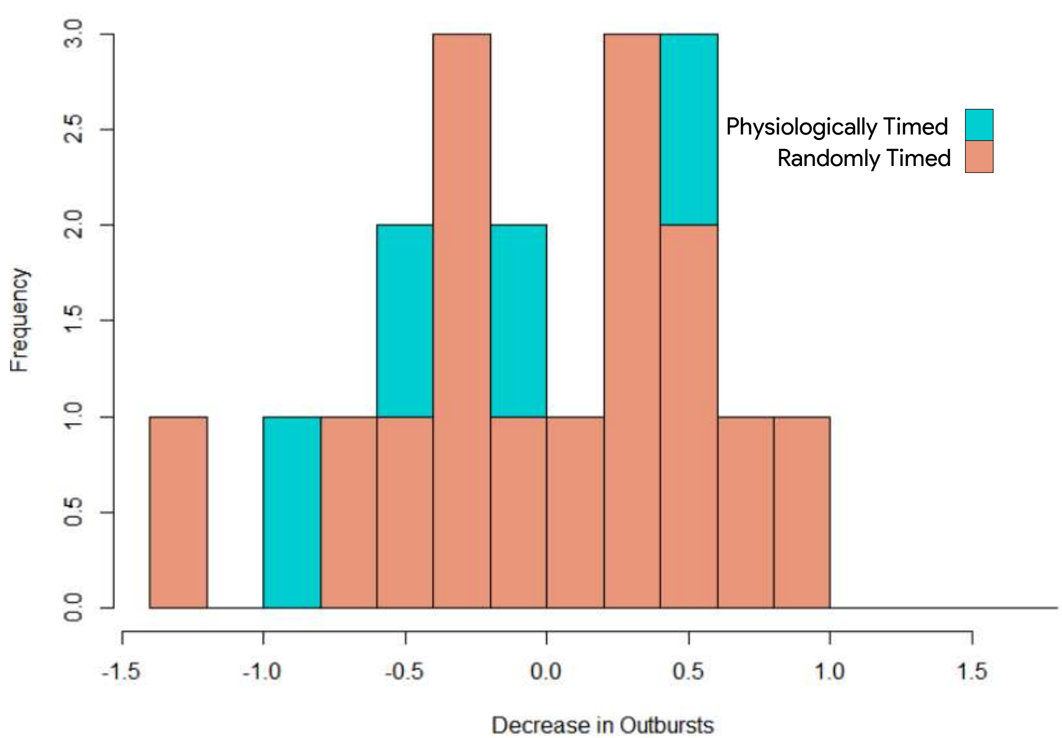

Figure 3. Hypothetical histogram of the decrease in mean outbursts when comparing Physiologically Timed and Randomly Timed relaxation interventions to the control period. This randomly generated data demonstrates no significant difference between the 3 periods, indicating that the relaxation technique was not effective.

There is also the possibility that the technique is effective but does not have an impact on the values being measured so we would still not see a significant difference. This would indicate a flaw in our study design in something like the quantification of the effects of the relaxation interventions or the monitoring devices. When determining the metrics to quantify how the different periods affected treatment outcomes, we wanted to utilize practical measures in our analysis that had more direct ties to the success of therapeutic sessions. This is why the metrics of session quality and number of outbursts were chosen over data that could be derived purely from the physiological sensors that were used, such as the mean time to return to baseline after crossing the individual's physiological thresholds for stress. There is also the possibility that the monitoring devices are not quite at the stage where a physiologically timed intervention would be effective due to a variety of factors, such as lag between the sensors and the individuals' actual physiological signals. If the data being received from the devices is not as accurate as we have been led to believe, it would be difficult to make any claims in support of our predicitons.

The third scenario is that the techniques are effective and do have and impact on the values measured, but the timing of the technique does not create a significant difference for the participants. This would be indicated by significant difference between the experimental periods and the control period, but no difference when comparing the changes between the physiological timed and randomly timed treatments. This result would tell us that it is not the timing of the breathing techniques that matters, but that the techniques are implemented at all. If this were to be the case, the implementation of Slow-Paced breathing techniques throughout the course of a therapeutic session could prove to be an affective form of mitigating stress in the individuals and should be considered for integration into treatment plans for individuals similar in age and ASD diagnoses to the participants of this study,

Future Research

If the physiologically timed relaxation intervention methods are proven to be affective, it may be beneficial to explore different ways of applying the concept of physiologically based treatment for individuals with autism. The first step in this process would be to extend the scope of this current research by broadening the participant group to better represent the entirety of the Autism Spectrum. This project had a subject group that would be relatively responsive and capable of learning and utilizing these techniques. ASD covers a broad spectrum of behaviors and conditions, and the present study may not be representative or applicable for the entire range of diagnoses. To include a larger portion of this population, future research could either increase the scope of diagnoses or the scope of ages.

The largest hurdle in increasing the scope of the study is the difficulty in applying the relaxation techniques. Younger children may have a greater difficulty following the directions of the therapists when implementing the techniques and children with more severe diagnoses may have similar issues. If these issues persist, it may be beneficial to explore another avenue of future research in different types of relaxation techniques that may be more widely applicable. Many children with ASD utilize items such as weighted blankets and stuffed toys to relax and alleviate stress (Seo et al. 2017). For individuals with a more difficult time learning the relaxation techniques, utilizing these tangible methods may prove to be an effective alternative for a physiologically based approach for stress management.

I also think it would be interesting to examine how physiology could be intertwined with preexisting methods for improving social behaviors, such as positively reinforcing individuals with ASD for completing tasks correctly. The concept of positive reinforcement uses a positive reward, such as social praise or a tangible toy, for a certain behavior in order increase the likelihood of the individual repeating said behavior in the future (Alsedrani n.d.). Exploring if physiological timed reinforcement yields more frequent and persistent favorable behaviors when compared to traditional positive reinforcement methods would further support a physiologically based approach to the treatment of Autism Spectrum Disorder.

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