

The Study of Fears and Its Interactions with the Brain

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Abstract

Fear is a natural response in the presence of danger, orchestrated by the amygdala, a key region in the brain for processing fear. The amygdala triggers the “flight or fight response” for multiple fears and phobias. Throughout this research paper, the effectiveness of different treatment methods for fears is explored by analyzing heart rate data from a FitBit. There is limited research on the efficiency of multiple fear therapies, and there is a lack of direct comparisons between fear therapies. This research paper sought to address the problem by directly comparing three different fear treatment methods. Types of fears tested include jumpscare, heights, oceans, bugs, no control during skiing, and darkness; using 17 people for the 3 different therapies: Visualization Therapy, Exposure Therapy and Cognitive Behavioral Therapy. For the comparative analysis, percent change was used in heart rate and used a different person for each treatment. The conclusion was that Cognitive Behavioral Therapy had the most profound effect in the experiments in treating fear as measured by the change in heart rate. It is shown that this was the most effective therapy because it includes a multi-step approach, which features an increase in “scariness” for each round of treatment, thus allowing for the brain to adapt and adjust.

Keywords: Visualization therapy, Cognitive behavioral therapy(CBT), Exposure therapy, Amygdala

1. Introduction

Many tests and studies have been done on the science behind fears; however, there is limited research about why certain methods of controlling fear work better than others. Also, only a few studies provide direct comparisons between various fear treatments, which leaves a gap in our understanding of their effectiveness. This experiment aims to identify the most effective methods of managing fear. To do this calculate the percent change of the participants heart rate for each of the experiments and the experiment with the highest percent change will mean it is the most effective treatment. Heart rate is a classic indicator of fear in an individual, therefore our goal is to lower the heart rate of the individual after encountering triggering stimuli through various fear therapies. With the information from this study, the dots can be connected to how people's brains respond to fears and how to manage the responses, leading to new insights about the brain and its interactions.

Fear is a natural response that living organisms have in the presence of danger or a threat. Fear is induced through a system of neural processes. When someone is introduced to a potentially dangerous situation, sensory information is processed by the brain. Fear can be identified through the presence of certain objects, imagined events, and the unknown, for example. The Amygdala receives information and stimuli which it interprets and then relays information to the body and the rest of the brain on what the fear is and what to do. The amygdala sends signals to other brain areas to activate the famous “fight-or-flight” response. A release of hormones, such as epinephrine, characterizes this response. Epinephrine plays roles in attention, focus, panic, and excitement, and it helps you prepare for dangerous or stressful situations like when facing fears, including common ones like Arachnophobia, Tryphobia, and

Acrophobia(Magazine, 2017). This sudden rush in hormones can be measured in many ways but the most straightforward way which is also used in this study, is measuring heart rate.

According to Psychology Today some researchers argue that fear cannot be classified since humans cannot quantify the act of being afraid. Still, others believe fear relates to other factors in the human body, such as heart rate, which is mainly used in the experiment for data collection. There is a need to understand which treatment methods are the most effective in reducing physiological fear responses to develop our understanding of the brain and treatment methods for patients to help more people. Fear results from evolution, originating from the human ancestor: hunter-gatherers. The amygdala likely originated from human ancestors to determine whether a situation was safe. The amygdala is now known to control strong emotions and plays an essential role in sensing and reacting toward fear.

The diagnosis of fears typically begins with a talk to your primary care provider. According to the National Library of Medicine, some of the fear therapies used are visualization therapy, exposure therapy, and cognitive behavioral therapy (CBT). Visualization therapy works by imagining a calming scenario while interacting with the fear. However, the other method that exists that was used in this experiment is about imagining facing the fear beforehand to counteract fear responses. Exposure therapy works by systemically exposing individuals to feared stimuli or situations in a controlled manner. CBT is based on both on a combination of exposure and visualization therapy. Currently, most research in this field comprises of three types of studies: comparing treatments using different medications, discussion on a single therapy(e.g. effectiveness of exposure therapy), or discussing a single therapy for a single fear(e.g. effectiveness of exposure therapy for fear of heights). Studies comparing various treatment methods using medications are common but don't test any purely physiological therapies. Although their is research discussing a single therapy and its effectiveness, it has yet to be compared with other therapies. Also, there are a variety of studies on the efficacy of a single therapy for a single fear, but they also lack a comparison to other fears or treatment methods. This study contributes to the current research by comparing therapies with each other using a multitude of fears for data to show which one is more effective in most cases.

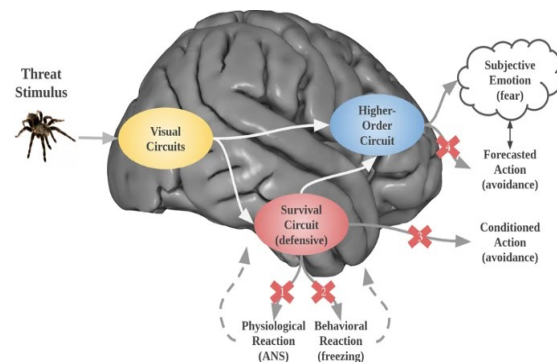


Figure 1. A visual map of how the brain parts react when identifying a potential threat. The image shows the order in which neural processes occur and potential outputs in response to the threat stimulus. A stimuli is presented to the individual and the brain process' this through the visual circuit which then connects to the higher-order circuit or cervical circuit based on type of stimuli. (Taschereau-Dumouchel et al., 2022)

2. Materials and Methods

The methods tested in this experiment include Visualization therapy, Exposure Therapy, and Cognitive Behavioral Therapy. The main premise is to compare an individual's heart rate initially and the heart after being exposed to the triggering stimuli. The fears were chosen by listing common fears and at any point, there was a situation where one of these fears could be tested, it would be done; for example, the fear of heights test was done at Six Flags with the people there. To begin, the fears to test were decided. This was done by taking common fear-inducers that have shown to be strongly influenced by fear therapies. Next, the best way to test each fear was determined (ex. testing a fear of bugs by showcasing varying insects). The jumpscare test was conducted by first collecting data about the people beforehand and then, usually a few days later, the jump scare would happen but before the jumpscare, it was ensured that the participant was wearing a FitBit for that duration(few days to a week) so the data could be tracked at the moment of the jumpscare but wouldn't tell them when it would be, which would ruin the data as they would know when the jumpscare was about to happen. The height test was done by bringing the subject to the roller coasters at New Jersey six flags where the coasters ranged from low/medium height to max height; the ocean test occurred at the beach; the bug test was done by introducing the participant to a variety of bugs. Also, the participants' heart rate data was tracked through a FitBit. The individual's heartrate was recorded before the test and again in the end. The percent

change was determined by calculating the difference from the final and the initial heart rate.

Picking out the participants for each test is an important step to allow for accurate results. Participants were chosen for the general study by being asked to participate which was mostly family and friends and the rest included random people found at the location the test was taking place. Each participant's pre-existing fears were taken into consideration to decide what trial they would be a part of. For example someone with the fear of bugs would participate in that test. Also it is important to have diversity within the study so a large age range was used, and in this experiment the age range used was 13 to 72 years old.

The Fitbit placement is important for accurate results. To have the most accurate results, place the scanner under the Fitbit directly on the wrist and tighten it to the point where the strap touches the other side but does not constrict it. For most of these activities, wrist movement was not needed; however, for something with wrist movement or exercise, like losing control during skiing, loosen the Fitbit slightly and move the Fitbit up the arm slightly. The Fitbit should be moved up the width of one thumb or less to allow for wrist movement while still recording the data accurately. Throughout this experiment, the Fitbit was placed on the left wrist, and between tests, the sensor was cleaned with the microfiber cloth used for glasses, but many alternatives work just as well. At the start of each test, data on the participants' baseline heart rate as well as their heart rate when interacting with the fear were collected; it was also noted before the tests if there were any previous experiences with the fear. This information gave a pre-assessment of the participants' baseline anxiety and their fear levels.

To perform each therapy, the first step is placing them in their corresponding groups, recording their natural heart rate and then by walking through the specific therapy. First, visualization therapy guides them through what they will face in their fear by having them close their eyes and telling them to imagine the situation the researchers will talk about. Talk to the participant in a slow, calm voice, describing the problem, the best outcome, making it seem as peaceful and relaxing as possible. Although not all situations can be peaceful, try to talk about the good emotions they will have. For something that has a peaceful setting like the ocean, talk about the cool, bright blue water and the breeze. While something that is not necessarily peaceful, like roller coasters to test fear of heights, talk about the wind rushing through hair, and beautiful view with the participant. It is important to leave out the bad and exaggerate the good to make it seem as relaxing as possible. Two to three sessions of about one minute were used for each participant in the visualization therapy group. Next, exposure therapy guides the participant through the fear they will face but gradually increases from a lower level to a larger level of fear. The fear of heights test, which took place in Six Flags was done by going from smaller rides to the final one where the initial test was done. However, something similar can be done for anywhere else the test is taking place. For the fear of bugs test, it was done by working up from an ant to a ladybug to a tiny worm, a dead fly, and then a spider. This was used in this experiment but many other combinations can be used. For exposure therapy, two to three sessions, which lasted anywhere from 2 minutes (shorter ones like fear of bugs) to a few hours (waiting in line for the roller coasters took considerable time for fear of heights), were used. Finally, CBT is done using a combination of visualization and exposure therapy. For this, the same setup as exposure therapy is used where there is a gradual increase from a low to a larger level of fear. At each level, visualization therapy was used to prepare the participants for what they are about to experience. For CBT, two to three sessions, which lasted from 4 minutes to a few hours were used depending on the situation and which fear was tested like in exposure therapy.

In order to test what methods for facing fears worked the best, the experiment was done on several people comparing their heart rate from when they were in a calm state to when they were thinking and/or looking at their fear. The first step was to record their current heart rate and then ask about fears. Asking about the individual's fear has been shown could increase heart rate slightly so it would result in inaccurate information. Using a FitBit which was located on the individual's wrist collected data on the subjects' heart rates. The location for each test was dependent on the particular stimuli. Most of these were straight forward like testing fear of heights by going to six flags and slowly building up to a large ride but for jumpscares, telling them that what was about to happen would be ineffective due to the participant having knowledge of the jumpscare beforehand. So instead it was told that the experiment would be conducted later within the next week after "data" on their resting heart rate was collected which was not done but was used to throw the person off guard allowing for accurate results. Attempted jumpscares should be done when the participant was least expecting it like for example when someone came downstairs to get some water.

3. Results

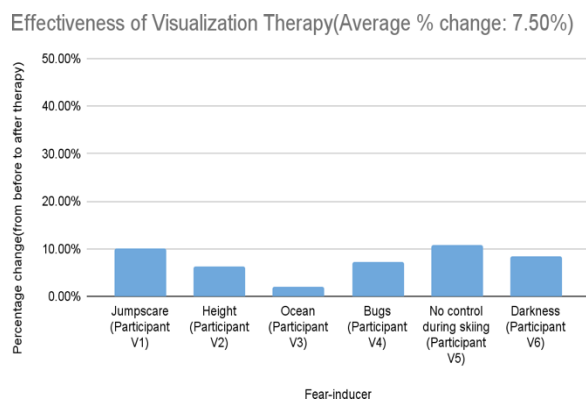


Figure 2: Data on Visualization Therapy with different participants
*Standard deviation for Visualization Therapy: 3.13%

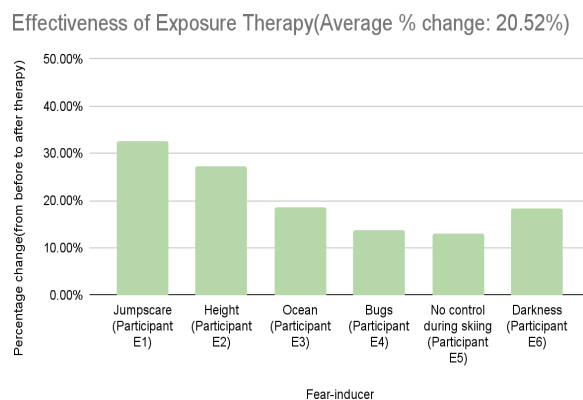


Figure 3: Data on Exposure Therapy with different participant
*Standard deviation for Exposure Therapy: 7.77%

4. Discussion

From the data it can see that CBT worked the best in reaction to jumpscare, height, ocean, and bugs. Also from the data, it was shown that a huge jump in effectiveness in therapy methods occurred when switching from Exposure Therapy to CBT. Even though there is a jump in effectiveness between Visualization therapy to Exposure Therapy, it is not as large from Exposure Therapy to CBT. For the fear of darkness the results show that CBT didn't help and was rather less effective than Exposure therapy. Looking at the percentage change there wasn't a substantial difference and this small difference wouldn't be statistically significant. Also, looking at the impact of CBT in all the other cases this one case seems to be an outlier.

It was concluded that the reason why Cognitive Behavioral Therapy worked the best was because it included a multi-step approach. Each step increased in difficulty allowing for the brain to adapt and adjust. The averages for the percentage change of CBT, Exposure therapy, and Visualization therapy are 25.15%, 20.52%, and 7.50% respectively. A higher percentage change is more favorable in this study. A high percentage change means that the heart rate from the time of stimuli occurrence to the time after the therapy had a large change. This means that the therapy would be effective to varying degrees if it lowered the hear rate and thus had a higher percentage change.

The data was interpreted by understanding the percent change in BPM. As a result of the "fight-or-flight" reaction, your heart rate increases. An effective fear therapy would help to lower the BPM. Thus, the higher the percent change, the more effective the fear therapy is. From the data it was shown that for the visualization therapy there were slight changes, which can be attributed to the fact that the amygdala was only slightly modulated resulting in low effects. Furthermore, something that was noticed throughout the experiments was that test subjects displayed improved emotional regulation through repeated actions. The improved emotion regulation might have been due to the prefrontal cortex, which is responsible for regulating and helping control fear based on past experiences and learned information. The repeated exposure through these tests may have helped change or influence that learned information. This effect

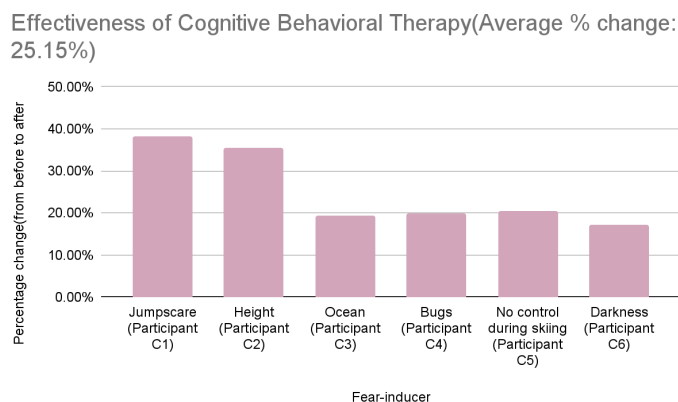


Figure 4: Data on Cognitive Behavioral Therapy with different participants
*Standard deviation for CBT: 9.24%
**Note: in this experiment only two people were used for fear of the ocean. One person took part in the first two sets of the ocean stimuli experiment

is not only something that applies to fears but to other events like practicing a problem multiple times will help you understand and remember it and a physical example of this is taking cold showers; the more you take cold showers the more you get over the uncomfortableness of being cold. A wide array of output was obtained for the mental part of overcoming fears, as tested through CBT and the visualization therapy.

From reviewing the standard deviation (SD) of each therapy, the widespread effectiveness of each therapy can be evaluated. The standard deviation values for cognitive behavioral therapy, exposure therapy, and visualization therapy are 9.24%, 7.77%, and 3.13%, respectively. This shows that CBT has the most spread-out data while visualization therapy has the least. A higher SD value means that the therapy has a large range in effectiveness, measured quantitatively through percent change in heart rate. Thus, CBT can be very effective for some triggering stimuli but not so much for other stimuli. Conversely, visualization therapy would be around the same level of effectiveness for each therapy. By looking at the figures and determining the difference between the stimuli with the max percentage change vs min percentage change, the stimuli that had the largest effect from the therapy versus the stimuli that had the smallest impact respectively, the SD means in terms of this study can be analyzed. By looking at Figure 4 (CBT therapy) the jumpscare participant showed a 38.27% change, while the darkness participant showed a 17.24% change. This large variation in the percent change of heart rate shows how CBT has a clear range in its effectiveness based on the stimuli. When looking at Figure 2 (visualization therapy), it can be seen that the participant with no control during skiing had a percent change of 10.71% while the height participant had a change of 6.32%. This shows that the effectiveness of this therapy remained relatively the same, although it was less effective when compared to CBT. Ideally, there should be one therapy type that is effective for all stimuli; however, due to the brain's complex nature, this is not realistic. As a result, when deciding which therapy to use for each stimulus it is important to note that there are discrepancies in the effectiveness of each therapy overall so it is crucial to closely examine that the chosen therapy works the best specifically for the stimuli of interest.

While conducting testing for ocean stimuli there was a limitation that could influence the results of this experiment, which was that the data collected for fear of the ocean might be skewed due to the fact that one individual utilized both visualization and exposure therapy techniques. On top of this, another limitation is the small sample size, which is only 17 people, which limits the generalizations that can be made. With larger pools of participants in the future, the accuracy could increase. However, this study still provides valuable initial insights that compare the effectiveness of these therapies. The different settings vary widely, and this variability in environments poses a limitation that may affect the consistency and reliability of the data. Because this data was not collected in a controlled environment, external factors like other people or distractions can influence the data, which limits the reliability. Furthermore, due to our limited resources, the only data that could be collected was heart rate. When studying fears it is important to note that hormones such as cortisol are released and your blood pressure increases when introduced to a triggering stimulus. However, there is no way to track these aspects of our experiment so only heart rate was tracked. In future studies, standardizing data collection in a controlled environment will allow for less variability and external influence, providing more accurate data and conclusions. This could also include using other methods to track the changes in the individual like blood pressure. The experiment showed that CBT was the most effective treatment based upon its most desirable heart rate change. However, a different fear therapy may be more effective because it can induce the desirable heart rate change and another factor, such as decreased blood pressure. Therefore, in future trials, it is essential to collect resources that allow for many tests. Furthermore, in our baseline tests conducted for each participant, a correlation between more intense interactions with fears and higher heart rates was present; however, no data proves whether this correlation still exists with extremes of this spectrum, which can be tested in future studies. This will show to what extent different fear therapies are most effective.

5. Conclusion

Our data shows that using CBT and Exposure Therapy work the best for lowering the final heart rate. Lowering the final heart rate in comparison to the initial heart rate, means that the therapy worked well to calm the individual following the stimuli. Phobias are highly prevalent within our society and can affect both men and women from all ages. This displays the clear need for an effective treatment for those with phobias. The research conducted here is

important as it can allow for further examination on the connection between fear and fear therapies. Researchers in the future can use the information from this study to determine what therapy works the best for each stimulus. More research into this field can hopefully lead to more effective therapies and increasing the accessibility of each therapy. However, when collecting the data, there existed some possible errors in the methodology which can lead to skewed data. The errors can be attributed to 2 main sources: the researcher and the heart rate monitors. When running the test, how the stimuli was presented may have elevated the participant's heart rate, not necessarily the physical stimuli. Additionally, the heart rate monitors such as the FiBit, may have needed to have been initially placed correctly or may have shifted during the test. This can lead to an inaccurate heart rate reading which would mess with the percentage change for heart rate, therefore making the effectiveness of each therapy method to be inaccurate.

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