MODIFICATION OF ANXIETY SENSITIVITY AND P300 USING AN
INTERPRETATION MODIFICATION PROGRAM

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Modification of Anxiety Sensitivity and P300 Using an Interpretation

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ABSTRACT OF THE THESIS

Modification of Anxiety Sensitivity and P300 Using an Interpretation Modification Program

by

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Master of Arts in Psychology
San Diego State University, 2016

Anxiety disorders are common, debilitating, and associated with functional impairment and cognitive biases, such as interpretation biases for negative information. Although efficacious treatments exist for these disorders, many affected individuals do not have access to them. One treatment that has been shown to be efficacious in the last 10 years for anxiety is computerized cognitive bias modification (CBM). Moreover, it is possible to use a specific form of CBM (interpretation bias modification, IBM) to reduce the negative interpretations and increase benign interpretations of ambiguous events, and this in turn can reduce anxiety responses to a stressor. Additionally, IBM interventions can reduce levels of anxiety about anxiety sensations (i.e., anxiety sensitivity, AS). However, studies demonstrating the effect of IBM on AS have not generalized to other response systems (e.g., reduction of physiological responding). To address this issue, in Experiment 1 I tested a single-session IBM intervention to determine if interpretation biases could be modified in 18 participants. In Experiment 2, I used electroencephalogram (EEG) before and after one session of IBM to measure the P300 in 10 undergraduates with high self-reported Anxiety Sensitivity Index (ASI) scores. For both experiments, I hypothesized that after one session of IBM participants would: 1) endorse more benign and fewer negative interpretations of ambiguous scenarios and 2) show a decrease in ASI scores; additionally, for Experiment 2 I hypothesized that IBM participants would: 3) show reduced P300 amplitude for the oddball stimuli. As predicted, there was a significant Time x Valence interaction in the training group for both experiments, such that negative biases significantly decreased and neutral biases did not significantly change. Also, ASI scores significantly decreased in Experiment 1, and there was a significant main effect of Time in Experiment 2 indicating that ASI scores significantly decreased across both conditions. Finally, P300 amplitude for oddball stimuli did not reduce over time. Results from this study suggest that individuals high in AS have interpretation biases that can be modified; however, a multi-session program or more participants may be needed to obtain differential reductions in AS or change of the P300.
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INTRODUCTION

Anxiety disorders are common and debilitating (Olatunji, Cisler, & Tolin, 2007). While, treatments for anxiety disorders are effective, they do not result in uniform reduction of symptoms (Bandelow et al., 2015). Partly in response to the less than complete remission of symptoms, researchers have used information processing models to develop more targeted treatments. Information models of emotional disorders postulate different components of anxiety including: 1) cognitive, 2) physiological, and 3) behavioral response systems. According to these models, these components interact to develop and maintain anxiety (Lang, 1968; Lang, McTeague, & Bradley, 2016). For example, when an individual with social anxiety gives a speech, she may think that everyone is judging her (cognitive); that can lead her to stuttering or sweating (physiological) and in turn leaving the situation (behavioral). These components are moderately correlated but are not present in every situation or to the same level in every individual. However, the components can be measured using different methodologies (Lang, 1968). For example, anxious individuals are not very accurate when asked to report their heart rate, sweat production, or face temperature (i.e., physiological responding) in anxiety provoking situations (Edelmann & Baker, 2002). Therefore, it is important to develop treatments that target each component of anxiety as these components can have bidirectional relationships.

One recent intervention that directly targets the cognitive component of anxiety is cognitive bias modification (CBM; MacLeod & Mathews, 2012). There is ample evidence that anxious individuals show habitual ways of attending to, remembering, and interpreting information in their environment (Mathews & MacLeod, 2005). More specifically, anxious individuals tend to pay attention to threat relevant information, interpret ambiguous information as threatening, and remember negative information disproportionally when compared to non-anxious individuals. These core cognitive biases also play a role in the maintenance and etiology of anxiety (Mathews & MacLeod, 2005). As such, interventions targeting these biases may reduce anxiety symptoms.
A core cognitive bias implicated in anxiety is the tendency to interpret ambiguous information as threatening (Butler & Mathews, 1983; Mathews & MacLeod, 2005; Menne-Lothmann et al., 2014). For example, when presented with the sentence, “You wake with a start in the middle of the night, thinking you heard a noise, but all is quiet,” individuals with anxiety tend to rate negative interpretations (i.e., “it could be a burglar”) as more likely than benign\(^1\) interpretations (i.e., "it was nothing," Butler & Mathews, 1983). These ratings are typically assessed using a Word-Sentence Association Paradigm (WSAP). In this task, researchers manipulate the presentation of word cues with sentences to display one word at a time with an ambiguous scenario. By measuring relatedness ratings for benign and negative words independently, it is possible to compare these ratings across individuals. Indeed, research suggests that individuals with social anxiety have lower levels of benign bias than individuals without social anxiety (Clark & McManus, 2002). Similarly, individuals with obsessive-compulsive disorder (OCD) have an interpretation bias for negative thoughts (Amir & Kozak, 2002).

Researchers have also manipulated the WSAP task to provide participants with feedback about their accuracy of their relatedness ratings. In this version of the task, individuals can be trained to reduce their negative interpretations and increase their benign interpretations. This change in interpretations can in turn reduce anxiety (for a review see Menne-Lothmann et al., 2014). For example, Clerkin and Teachman (2011) found that after one session of IBM individuals with OCD had reduced negative interpretations, increased benign interpretations, and less negative affect when presented with an obsessive compulsive stressor. Similarly, Beard and Amir (2008) found that after eight sessions of IBM, individuals with social anxiety had reduced negative interpretations, increased benign interpretations, and decreased social anxiety, and this decrease in social anxiety was mediated by the change in benign interpretations. These studies show that interpretations play a causal role in the treatment of social anxiety and OCD, and one such interpretation that is implicated in various forms of anxiety is the interpretation that anxiety sensations are negative (anxiety sensitivity).

---

\(^1\) Researchers use different terms to refer to interpretation biases (threat, negative, non-threat, neutral, benign, positive). From this point on I will mostly use the terms ‘negative’ and ‘benign’ (the combination of neutral and positive).
Anxiety sensitivity (AS) is defined as the tendency to interpret anxiety sensations as dangerous (e.g., racing heart means the person is having a heart attack rather than a normal fluctuation; Reiss, Peterson, Gursky, & McNally, 1986). AS is implicated in many anxiety disorders as a predictive and maintaining factor, and thus, researchers have attempted to reduce AS using different treatment methods. Three studies have attempted to modify AS by using interpretation modification methods.

First, Steinman and Teachman (2010) used a task where participants imagined themselves in an ambiguous situation (e.g, "You are jogging. Your heart starts to beat quickly"). The situation remained ambiguous until the last sentence. The last sentence then disambiguated the scenario to be either positive (e.g., "This is in_igorating.") or negative, (e.g., "This is dan_rous."). Participants filled in the missing letter to complete the word that disambiguated the sentence. In the IBM condition, participants only saw positive endings; while in the control condition, participants saw an equal number of positive and negative endings. Participants then completed a recognition task as a manipulation check where they rated four new endings for scenarios that were presented during the training (related positive, related negative, unrelated positive, unrelated negative) on their relatedness to the scenarios. Finally, participants completed a behavioral avoidance task (BAT). During the BAT, participants breathed through a small straw or pretended to blow out candles in order to examine the effect of IBM on anxiety reactivity. Steinman and Teachman (2010) found that the IBM group rated AS positive endings as being more related than AS negative endings during the recognition task. Moreover, ASI scores decreased from pre to post in the IBM group but not in the control group. They did not find, however, a significant difference between the two groups in completion or fear of the BATs. Steinman and Teachman (2010) attributed these null findings to the fact that most of the participants completed at least one of the BATs. However, it is also possible that the IBM program was not ideal for modifying interpretations.

MacDonald, Koerner, and Antony (2013) extended the findings of Steinman and Teachman (2010) using a WSAP to modify AS in individuals with high ASI scores. The WSAP comprised 64 ambiguous sentences (e.g., "You laugh so much that it feels like you can’t get enough air.") that could be related to either a negative (e.g., horrifying) or benign (e.g., enjoyable) word. Participants were asked to decide whether or not the word and the
sentence were related. In the training condition, the participant received feedback about whether or not they were correct, and the control condition received feedback that was not contingent on their response. Participants were assessed for interpretation biases before and after the training using the Brief Bodily Sensations Interpretation Questionnaire (BBSIQ) in which participants rated the plausibility of negative or benign endings of ambiguous situations and then ranked these situations in order of which was most likely to happen. Finally, participants completed two BATs (chair spinning and straw breathing). MacDonald et al. (2013) found that AS decreased over time in the training condition, but there were no significant differences between groups at posttest. Moreover, in the training condition, there was a decrease in the ranking placement of negative explanations, and an increase in the plausibility of the benign explanations. Finally, MacDonald et al. (2013) did not find differences in fear ratings or time spent engaging in the BAT. Similar to Steinman and Teachman (2010), MacDonald et al. (2013) attributed the null findings of the BAT differences to the fact that most participants were able to complete the BATs. However, since there was no decrease in the plausibility of negative explanations, the participants may not have received the active ingredient of IBM (decrease in negative and increase in benign interpretations), which could explain the null findings.

Finally, Clerkin, Beard, Fisher, and Schofield (2015) attempted to extend and replicate previous research by utilizing two training sessions rather than one to modify AS. Their control condition also differed in that they used benign words (instead of panic related words) and gave the participants feedback. Participants were assessed for interpretation biases before and after the training using the same sentences as the training, but the participants were not given feedback about whether or not they were responding correctly. Finally, participants completed three BATs (jumping jacks, candle blowing, and chair spinning). Clerkin et al. (2015) found that individuals with more negative interpretation biases had higher ASI scores before and after the training and that ASI scores reduced overtime, across conditions. Moreover, in the training condition, participants endorsed more benign and less negative interpretations after the training than before the training while the control condition only endorsed more benign interpretations. Finally, there were no group differences in peak anxiety during the BATs (Clerkin et al., 2015). Thus increasing the number of sessions did not enhance the training effect.
In summary, three studies have examined the effects of interpretation modification in individuals with elevated ASI scores. All three studies found evidence for reduction of interpretation bias as well as ASI scores in the IBM condition. However, Clerkin et al. (2015) also found decreases in AS in the control group and MacDonald et al. (2013) found no group differences at post assessment between AS in the control and training groups. Additionally, none of the studies found evidence for an effect of IBM training on fear responses during the BATs when compared to the control group. Finally, none of these studies examined the effect of IBM on physiological markers of anxiety. Thus, the current study sought out to examine the effect of IBM on physiological markers of anxiety.

The P300 is an event-related potential (ERP) that may be an indicator of sensitivity to unusual or unexpected stimuli (Donchin, 1981; Polich, 2007). This sensitivity to unusual stimuli may be a representation of perception of frequency rather than the actual frequency. Thus, the P300 represents an updating of schema and not an actual response to an event, and the degree to which the schema requires updating determines the P300 size (Donchin, 1981). Therefore, P300 has been used to assess sensitivity to unexpected stimuli in individuals with anxiety that may be expecting negative information more than benign information. Accordingly, individuals with anxiety may have either: 1) increased amplitudes when responding to benign information compared to negative information or 2) lack of a difference in response amplitudes between benign information and negative information. On the other hand, non-anxious individuals may show increased amplitudes for negative information compared to benign information.

To investigate P300 and its relationship to interpretation bias, Moser, Hajcak, Huppert, Foa, and Simons (2008) examined the differences in P300 and P600 in individuals with high and low in social anxiety. These researchers found larger P300s in the high anxious group than low anxious individuals, although these differences were only marginally significant. They also found an interaction between anxiety group and sentence ending, such that the P300 was larger for negative words than positive words in the low anxious group. No such difference existed between word types in the high anxious group (Moser et al., 2008). This study demonstrates that differences in interpretation bias in anxious and non-anxious individuals have corresponding physiological signatures. To our knowledge, however, no studies have attempted to modify the P300 by modifying interpretation biases.
Although researchers have not used IBM in order to influence the P300, there is reason to believe that single session experimental manipulations can affect the P300. For example, Conti, Moscon, Fregni, Nitsche, and Nakamura-Palacios (2014) used transcranial direct current stimulation (tDCS) in individuals with a crack-cocaine addiction. Participants saw either neutral or crack-related pictures and were asked to press a button if the picture was crack-related or do nothing if picture was not related to crack. After one session of tDCS, the P300 intensity decreased for crack-related pictures and increased for neutral pictures; that is, participants found the crack-related pictures to be more unexpected than the neutral pictures (Conti et al., 2014). This study demonstrates that the P300 can be modified by a single session manipulation, and while the P300 is sensitive to unexpected stimuli, a decrease in amplitude of the P300 to unexpected stimuli (e.g., oddball stimuli) could suggest an overall decrease in sensitivity to unexpected events (i.e., ambiguous situations).

In the current study, I conducted two experiments. In Experiment 1, I assessed the utility of a WSAP in modifying interpretation bias such that individuals would endorse more benign and fewer negative interpretation of ambiguous scenarios. In Experiment 2, I used the WSAP to modify interpretation bias and examine the effect of this manipulation on AS and the P300. For both experiments, I hypothesized that after one session of IBM participants would: 1) endorse more benign and fewer negative interpretations of ambiguous scenarios and 2) show a decrease in ASI scores; additionally, for Experiment 2 I hypothesized that participants would: 3) show reduced P300 amplitude for the oddball stimuli.
EXPERIMENT 1

METHOD

Participants

Participants were 18 undergraduates recruited from an undergraduate psychology class for extra credit. Participant demographics are presented in Table 1.

Table 1. Demographics of participant

<table>
<thead>
<tr>
<th></th>
<th>Experiment 1</th>
<th>IBM (n = 5)</th>
<th>Control (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (% female)</td>
<td>61.1%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Age</td>
<td>22.83(2.96)</td>
<td>20.80(1.92)</td>
<td>20.80(2.39)</td>
</tr>
<tr>
<td>Education</td>
<td>15.28(1.02)</td>
<td>14.40(1.67)</td>
<td>14.00(1.87)</td>
</tr>
</tbody>
</table>

Note. Numbers are reported as M(SD) unless otherwise noted.

Assessments

WORD SENTENCE ASSOCIATION PARADIGM (WSAP)

In this task, participants saw a sentence on the screen. The sentence was ambiguous in meaning and could be interpreted as either negative or benign depending on the word that appeared after the sentence (Table 2). The sentence then disappeared and a benign or panic related word appeared on the screen. The participant chose if the word was related to the sentence or not by clicking the left or right mouse button. Each sentence is presented twice: once with the word associated with panic and once with a benign word. This task had two assessment phases and a training phase.

Table 2. Example WSAP sentences paired with possible words.

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Panic Word</th>
<th>Neutral Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>After a long day your vision blurs.</td>
<td>Stroke</td>
<td>Tired</td>
</tr>
<tr>
<td>Your heart starts racing after drinking coffee</td>
<td>Panicking</td>
<td>Caffeine</td>
</tr>
<tr>
<td>Your thoughts race when you engage in a heated debate</td>
<td>Crazy</td>
<td>Ideas</td>
</tr>
<tr>
<td>You are at a restaurant and start to feel nauseous</td>
<td>Vomit</td>
<td>Indigestion</td>
</tr>
</tbody>
</table>
Assessment phases

In the first assessment phase, participants made selections about the relatedness of the word for 20 ambiguous sentences but were not given feedback about their choice. The second assessment phase assessed interpretation bias change after the training phase (see below). This assessment phase was the same as the first assessment phase. To ensure that participants were not simply learning the correct interpretations for the same sentences, each phase had a different set of sentences.

Training phase

Next, participants completed the training phase. During this phase, the participants made selections about the relatedness of the word for 100 ambiguous sentences. Dissimilar to the assessment phase, the participant received feedback about whether or not they were responding correctly. The participant saw a blue ‘+3’ when they received feedback that they were correct and a red ‘-1’ when they received that they were incorrect. If the participant selected the benign word as being related to the sentence they received the feedback that they were correct. On the other hand if they chose the threat related word as being related to the sentence they received the feedback that they were incorrect.

Anxiety Sensitivity Inventory (ASI)

The ASI is a 16-item self-report inventory that assesses interpretation of anxiety provoking symptoms (Reiss et al., 1986). Participants rated the extent to which symptoms are experienced (e.g., "It scares me when my heart beats rapidly."). The ASI uses a scale from 0 (Very Little) to 4 (Very Much). I administered the ASI before and after the training.

Procedure

I first read a brief description of the study to the participants and asked them to complete an informed consent form. After they consented, participants completed self-report measures and then completed the first interpretation assessment phase. They then completed an orientation to the WSAP program. After completing the WSAP, participants completed the second interpretation assessment phase. Participants were then debriefed and compensated with extra credit for their time.
RESULTS

A 2 Valence (negative, benign) X 2 Time (pre, post) within group, repeated measure
ANOVA revealed a significant main effect of Time, $F(1, 17) = 27.80, p < .001, \eta^2_p = .62,$
such that overall endorsement was higher before IBM ($M = 61.5\%, SE = 3.0\%$) than after
IBM ($M = 46.9\%, SE = 2.6\%$). Also, there was a significant main effect of Valence, $F(1, 17)
= 47.29, p < .001, \eta^2_p = .74,$ such that negative words ($M = 37.9\%, SE = 4.3\%$) were endorsed
less than benign words ($M = 70.6\%, SE = 2.2\%$). There was also a significant Time X
Valence interaction, $F(1, 17) = 24.78, p < .001, \eta^2_p = .59$ (Figure 1). Individuals endorsed
benign words significantly more after IBM than before IBM, though this effect was
marginally significant, $t(17) = -1.88, p = .08$, and individuals endorsed negative words
significantly less after IBM than before IBM, $t(17) = 6.23, p < .001$.

Experiment 1

![Graph 1](image1)

Experiment 2

![Graph 2](image2)

**Figure 1.** Endorsement Rates for Negative and Neutral Words in Relation to an
Ambiguous Sentence Before and After the IBM Program. **p < .05  *p < .001**

Additionally, a t-test was conducted to assess the change in ASI from pre to post. ASI
significantly decreased from before the IBM to after the IBM, $t(11) = 2.79, p = .01$ (Figure
2).
DISCUSSION

Experiment 1 demonstrated that interpretation biases can be modified. Moreover, there was a decrease in the ASI from before to after training. Experiment 1, however, was in an unselected sample. Moreover, I did not assess behavioral or physiological responding or have a control group for comparison. Therefore, in Experiment 2 I added a control group and assessed physiological responding before and after training in individuals with elevated ASI scores.
EXPERIMENT 2

Experiment 2 used the same IBM program and self-report measures as Experiment 1. However, I only included participants with elevated ASI scores. Moreover I also added an oddball task, electroencephalogram (EEG), and a control group where interpretation biases were not manipulated.

METHOD

Participants

Participants were 10 undergraduates with high levels of AS recruited from the undergraduate research pool (see Figure 3 for a consort chart of participant recruitment). Participants were invited to participate in the study if they had an ASI score that was 28 or higher. This score is one standard deviation above the mean ASI score in a nonclinical population (Peterson & Reiss, 1992). I then randomly assigned each participant to either a control condition (CC) or the active condition (WSAP). Participant demographics for each group are presented in Table 1, p. 7).

Figure 3. Consort Chart of Recruitment of Participants for Experiment 2. The four participants who did not complete comprised: equipment issues (n = 1) and too much blinking (n = 3). One individual’s EEG data was not usable due to repeating alpha waves, and thus was not used to test Hypothesis 3.
POWER ANALYSIS

I conducted a power analysis using G*Power to determine the number of participants needed for Experiment 2 (Faul, Erdfelder, Buchner, & Lang, 2009). Using an average effect size observed in the previous studies (Clerkin et al., 2015; MacDonald et al., 2013; Steinman & Teachman, 2010) for the interaction of time and training condition on ASI scores ($\eta_p^2 = .04$), an alpha value of .05, and the test-retest reliability of the ASI ($r = .75$; Reiss et al., 1986), this analysis suggested that a $n$ of 26 would provide .81 power for a 2 Time (pre, post) x 2 Group (IBM, control) repeated measures ANOVA with between factors.

Similarly for the P300 effect size I used the following parameters: an average effect size observed in the previous studies (Conti et al., 2014; Karaaslan, Gonul, Oguz, Erdinc, & Esel, 2003; Su, Cai, Shi, & Wang, 2012) for change in P300 amplitude before and after treatment ($\eta^2 = .06$), an alpha value of .05, and the test-retest reliability of the amplitude of the P300 ($r = .81$; Brunner et al., 2013). An $n$ of 14 would provide .80 power for a 2 Time (pre, post) x 2 Group (IBM, control) repeated measures ANOVA with between factors.

Assessments

ODDBALL TASK

The oddball task is a widely used task to measure P300 (Polich, 1998). It has good test-retest reliability and validity (Polich, 2007). In this task, researchers recorded EEG (see below) while participants were presented with black circles and squares on a computer screen with a light grey background. Each stimulus remained on the screen for 100ms with an interstimulus interval of 2000ms. Participants clicked the left mouse button with their index finger of their dominant hand when they saw the target stimulus and the right mouse button with their middle finger when they saw the standard stimulus. Target and standard stimuli were counterbalanced such that half of the participants had the circle as the target stimulus and half of the participants had the square as the target stimulus. Standard stimuli were presented with 80% frequency (120 trials) and target stimuli were presented with 20% frequency (30 trials) for a total of 150 trials.
WSAP

This task was the same as the task used in Experiment 1; however, in the assessment phases I added 10 sentences to the pool of sentences (participants saw 30 sentences instead of 20). The training phase was the same as in Experiment 1; however, some participants were assigned to the control condition for Experiment 2. In the control condition, after making the selection about whether or not the word and sentence were related, the participant received feedback that they were correct or incorrect on 50% of the trials respectively. The active condition was the same as in Experiment 1.

EEG DATA RECORDING AND ANALYSIS

I recorded EEG data using an electrode cap (EasyCap GmbH, Herrsching-Breitbrunn, Germany) and an ActiCHamp amplifier system (Brain Products GmbH, Munich, Germany) from 32 electrodes (Fp1, Fz, F3, F7, FT9, FC5, FC1, C3, T7, TP9, CP5, CP1, P3, P7, O1, Oz, O2, P4, P8, TP10, CP6, CP2, Cz, C4, T8, FT10, FC6, FC2, F4, F8, Fp2, and Pz). All electrodes were referenced to Cz and a ground electrode placed in the middle of the forehead. I filtered the EEG using an anti-aliasing low pass filter at 130 Hz and digitized at 500 Hz with 24 bits of resolution.

I performed all offline data analyses using MATLAB 2012b, EEGLAB open source tool box (Delorme & Makeig, 2004), and the ERPLAB toolbox (Lopez-Calderon & Luck, 2014). In accordance with Polich (1998), I re-referenced the EEG data to the average of TP9 and TP10, band-pass filtered the data between .01 and 30Hz, and single trials in which the EEG exceeded ±100 µV were automatically rejected. I then segmented the data for each trial beginning 100ms before stimulus presentation and continuing for 900ms after stimulus presentation (Polich, 1998). Finally, trials with response times (RTs) outside of 200-2000ms were excluded from analyses. P300 was calculated using the mean amplitude at Pz within a 250-500ms window, post-stimulus (Polich, 1998).

Procedure

I first read a brief description of the study to the participants and asked them to complete informed consent. After they consented, participants completed self-report measures and then had the EEG cap and electrodes placed on their head. Participants then completed the first assessment phase with the oddball task and interpretation assessment.
Then, I completed an orientation to the WSAP program with directions that were specific to each condition. After completing the WSAP, participants completed the second assessment phase (oddball task and interpretation assessment) and self-report measures again. Participants were then debriefed and compensated with research credit for their time.

RESULTS

Change in endorsement

A 2 Valence (negative, benign) by 2 Time (pre, post) by 2 Group (active, control) mixed measures, repeated measure ANOVA was conducted to assess change in endorsement between groups and across time. There was a significant main effect of Valence, $F(1, 8) = 49.61, p < .001, \eta^2_p = .86$, and three significant 2-way interactions: Time x Group, $F(1, 8) = 11.75, p = .009, \eta^2_p = .60$; Valence x Group, $F(1, 8) = 15.11, p = .005, \eta^2_p = .65$; and Time x Valence, $F(1, 8) = 12.25, p = .008, \eta^2_p = .61$. There was no significant main effect of group. These effects were modified by a significant Time by Valence by Group interaction, $F(1, 8) = 15.64, p = .004, \eta^2_p = .66$ (Figure 1, p. 9). To examine this interaction further I performed simple effects analysis by dividing the data by Group and conducted a 2 Time (pre, post) by 2 Valence (negative, neutral) within group, repeated measures ANOVA.

TRAINING CONDITION

There was a marginally significant main effect of Time, $F(1, 4) = 5.82, p = .07, \eta^2_p = .59$, such that overall endorsement was higher before IBM ($M = 62.7\%, SE = 5.5\%$) than after IBM ($M = 51.3\%, SE = 1.0\%$). Also, there was a significant main effect of Valence, $F(1, 4) = 159.40, p < .001, \eta^2_p = .97$, such that negative words ($M = 33.3\%, SE = 4.2\%$) were endorsed less than benign words ($M = 80.7\%, SE = 3.0\%$). Finally, there was a significant Time by Valence interaction, $F(1, 4) = 16.96, p = .015, \eta^2_p = .81$. Individuals endorsed benign words significantly more after IBM than before IBM, though this effect was marginal, $t(4) = -2.59, p = .06$, and individuals endorsed negative words significantly less after IBM than before IBM, $t(4) = 3.99, p = .016$.

CONTROL CONDITION

There was a marginally significant main effect for Time, $F(1, 4) = 6.09, p = .07, \eta^2_p = .60$, such that overall endorsement was lower before IBM ($M = 61.0\%, SE = 5.6\%$) than after
IBM ($M = 76.0\%, SE = 8.8\%)$. The main effect Valence [F(1,4) = 3.07, $p = .16$, $\eta^2_p = .08$] and the interaction of Valence X Time [F(1,4) = 0.27, $p = .62$, $\eta^2_p = .07$] was not significant.

**Change in ASI**

A 2 Time (pre, post) by 2 Group (active, control) mixed repeated measures ANOVA was conducted to assess differences between groups in ASI over time. There was a significant main effect for time, $F(1, 8) = 7.19$, $p = .028$, $\eta^2_p = .47$, such that overall ASI was higher before IBM ($M = 34.3$, $SE = 1.72$) than after IBM ($M = 27.3$, $SE = 3.24$). There was no significant interaction of Group by Time (Figure 2, p. 10); however, the effect size was similar to previous studies, $F(1, 8) = 0.71$, $p = .42$, $\eta^2_p = .08$, current study; $\eta^2_p = .04$, average from Clerkin et al. (2015), MacDonald et al. (2013), and Steinman and Teachman (2010).

**ERP Analysis**

After visual inspection of the data, one participant (11713) was dropped from the ERP analyses due to repeating alpha waves in the EEG data (Figure 4). I successfully elicited the P300 to unexpected stimuli (i.e., the oddball) in the oddball task (Figure 5) such that the amplitude for the oddball was larger than the amplitude for the standard at pre, $t(8) = 2.13$, $p = .06$, and at post, $t(8) = 3.38$, $p = .01$.

![Figure 4. Individual ERP plots for Oddball Task. Shaded area is the P300 window (250-500ms)](image-url)
After the manipulation check was completed, the amplitude for the oddball stimuli was entered in a 2 Time (pre, post) x 2 Group (active, control) mixed, repeated measures ANOVA. There was no significant main effect for Time \([F(1,7) = 1.51, p = .26, \eta^2_p = .18]\) and there was no significant Time by Group interaction \([F(1,7) = 0.67, p = .44, \eta^2_p = .09]\) (Figure 6).
GENERAL DISCUSSION

The current study aimed to investigate the modification of interpretation biases through an IBM program and to evaluate the relationships between interpretation biases, AS, and physiological responding (P300). This study advanced previous literature by measuring the P300 before and after IBM to assess the effect of IBM on a physiological measure of expectancy.

As predicted, IBM was effective in modifying interpretation biases in individuals with elevated AS in the active condition. In contrast, individuals in the control group did not show a change in their interpretation biases. Individuals in the training condition learned to reject negative words and endorse benign words, and as a result, trained their interpretations. As the stimuli used for testing interpretation were a different set than the training set, the observed changes in interpretation biases cannot be attributed to familiarity with specific sentences, but rather can be attributed to a general learning effect of how to interpret ambiguous situations.

Contrary to the second hypothesis, AS did not decrease differentially across groups, but instead decreased over time for both groups. There are a number of possibilities that could account for this lack of group differences. First, the study sample size was small, limiting the power to detect group difference. Consistent with this hypothesis, the observed effect size in the current study was similar to previous studies that did find significant differences between AS in the training and control group.

Second, exposure to the interpretation sentences, regardless of contingency (i.e., active or control group) may have resulted in a reduction of ASI score in both groups. Future research should investigate what control condition is the best comparison for IBM (e.g., random feedback, benign words only, no feedback, etc.) as there is no consensus in the literature regarding the appropriate control condition for this task (Beard & Amir, 2008; Clerkin et al., 2015). The control condition in the current study, however, is one example of a task which did not result in modification of interpretation biases in the task.
Finally, the third hypothesis that the P300 amplitude for the oddball stimuli would be reduced was also not supported. As with the second hypothesis, it is possible that low power was responsible for this lack of significance. If low power was indeed responsible for the lack of significant effects, and a larger sample proved the trend level effect in the current study significant, these data suggest an opposite effect than what I hypothesized (i.e., in the IBM group, amplitude for the oddball stimuli was increased). This could indicate that the oddball task is mirroring the interpretation paradigm and that the oddball stimuli are seen as threatening, as compared to the standard stimuli. Given that the IBM trains the participant that threatening information should be more unexpected and thus rejected, an increase in amplitude for threatening stimuli or stimuli that are seen as threatening would be expected. It is also possible that the oddball task induced a more general awareness to stimuli in the environment, and thus heightened the response to the oddball stimuli, making it especially unexpected.

Finally, it is also possible that a single session of an IBM is not powerful enough to alter physiological responding. While many medical interventions have a clearly defined mechanism of action and active dosage, IBM does not currently have guidelines for what would be an “active dosage.” Future studies should explore different “dosages” of IBM and attempt to modify the P300 through a multi-session IBM program to determine how many sessions are needed to see physiological changes.

These limitations notwithstanding the results from this study show individuals with high AS have interpretation biases towards negative information that can be modified. This modification also leads to reductions in anxiety sensitivity across conditions.
REFERENCES


