STRESSOR CONTROLLABILITY AND MOTIVATED ATTENTION TOWARD NEGATIVE AND NEUTRAL PICTURES: AN EVENT-RELATED POTENTIAL STUDY

An Undergraduate Research Scholars Thesis

by

GINA THOMAS

Submitted to the Undergraduate Research Scholars program at
Texas A&M University
in partial fulfillment of the requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by Research Advisor: Dr. Annmarie MacNamara

May 2018

Major: Psychology

TABLE OF CONTENTS

ABSTRACT

Stressor Controllability and Motivated Attention Toward Negative and Neutral Pictures: An Event-Related Potential Study

Gina Thomas
Department of Psychological and Brain Sciences
Texas A&M University

Research Advisor: Dr. Annmarie MacNamara
Department of Psychological and Brain Sciences
Texas A&M University

Initial experiences of control/uncontrollability may affect subsequent encounters with stressors. Here, 48 participants completed an S1-S2 task, in which they passively viewed a negative or neutral picture (S1); following S2 onset (same picture, different border), they could push a button to make the picture disappear under conditions of control. One group (n=25) experienced controllability (Control Block 1, C1), followed by loss of control (No Control, NC) and then resumption of control (Control Block 2, C2); another group (n=23) experienced uncontrollability (NC), followed by two control blocks (C1, C2). Event-related potential, the late positive potential (LPP) was used to index motivated attention to S1 and the post-imperative negative variation (PINV) was used to assess perceived changes in stimulus controllability following S2 onset. Group and block interacted, $F(2,46) = 2.94$, $p <. 05$, such that among participants who started with control, loss of control increased the LPP and this effect persisted even after restitution of control (i.e. NC $M = 1.33$, $SD = 3.24$ > C1, $M = .09$, $SD = 3.50$ < C2, $M = 1.69$, $SD = 4.11$). In addition, larger PINVs during the NC ($M = 3.21$, $SD = 3.90$) compared to control (C1, $M = 5.34$, $SD = 5.00$; C2, $M = 4.97$, $SD = 4.45$) conditions were observed for the early time window, 400-800 ms after S2 onset. During the late time window (1,000-2,000 ms

after S2 onset), NC and C2 conditions elicited a larger PINV than C1 (i.e. NC $M = 4.17$, $SD = 4.63$ > C1, $M = 6.64$, $SD = 6.98$ < C2, $M = 4.70$, $SD = 5.23$). Therefore, among those with a contingent response-outcome history (i.e., participants who started with control), uncontrollable stress may lead to persistent increases in motivated picture processing (LPP). Additionally, the early PINV may be especially sensitive to *uncontrollability*, whereas the late PINV may reflect more elaborated processing of *changes* in stimulus controllability.

CHAPTER I

INTRODUCTION

Stressor controllability is associated with psychological well-being, whereas stressor uncontrollability may characterize a number of psychopathologies. Effects of stressor uncontrollability include motivational, cognitive, and emotional deficits as well as structural brain changes (Breier, 1989) that are in line with the fundamental characteristics of depression and anxiety. Thus, it has been proposed that exposure to uncontrollable stress might play a critical role in the etiology of these disorders (Maier & Watkins, 2005; Simson, Weiss, Hoffman, & Ambrose, 1986). Despite these findings, only a small number of studies have examined the brain correlates of uncontrollable stress in humans. The effects of uncontrollability over negative and neutral pictures has not yet been examined, and investigating its effects might help in understanding the behavioral and physiological consequences of uncontrollable stress exposure. Additionally, prior work (Diener, Struve, Balz, Kuehner, & Flor, 2009) has suggested that initial experiences of control/uncontrollability may affect subsequent encounters with stressors. Knowing how the brain responds to shifts in control may help in understanding the role avoidance and controllability play in well-being, and potentially in depressive and psychopathological emotion processing.

Event related potentials (ERPs) are voltages generated in the brain in response to specific stimuli or events (Blackwood & Muir, 1990). They are electroencephalogram changes that are time locked to motor, cognitive or sensory events that provide a noninvasive method of studying mental processes. Thus, ERPs provide an exceedingly reliable medium to index the processing of controllable and uncontrollable stimuli and motivated attention toward negative and neutral pictures. The post imperative negative variation (PINV) is a frontally maximal ERP component

that typically begins after the onset of the participant's response period, and can be used to assess neural response to controllable and uncontrollable stimuli. Early work examining the PINV has shown that in healthy individuals, enhanced PINV magnitudes have been found during unexpected shifts in control (Elbert, Rockstroh, Lutzenberger, & Birbaumer, 1982; Rockstroh, Elbert, Lutzenberger, & Birbaumer, 1979). The late positive potential (LPP) is a centro-parietally maximal ERP component that begins around 300–500 ms after stimulus onset, and is larger for emotional compared to neutral stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Foti, Hajcak, & Dien, 2009; Hajcak, MacNamara, & Olvet, 2010).

PINVs are typically elicited during an S1-S2 paradigm task, where a warning stimulus (S1) acts as a cue for the appearance of an imperative stimulus (S2). During S1, the participant must remain passive until the onset of S2, which indicates the participant can respond in some way. For example, a recent study (Diener, Struve, Brusniak, Kuehner, & Flor, 2009) used an S1-S2 paradigm to assess effects of stressor controllability on patients with major depression and dysthymia. S1 was a tone of 1 s duration, immediately followed by S2, in which subjects were instructed to respond by pressing the correct button in order to avoid aversive electrical stimulation.

Few studies have investigated the PINV using emotional stimuli. One recent study (Casement, Shestyuk, Best, Casas, Glezer, Segundo, & Deldin, 2008), aimed at assessing anticipation for future affective events at a neurophysiological level, used positive, negative, and neutral adjectives to study individuals with dysthymia compared to healthy controls. They found that PINV amplitudes were larger in response to neutral compared to positive adjectives, and that individuals with dysthymia had larger PINV amplitudes than healthy controls. These results are consistent with literature demonstrating larger PINV amplitudes in participants with major

depression compared to healthy controls (Kessler, Munz, & Trau, 1992; Knott, Lapierre, De Lugt, Griffiths, Bakish, Browne, & Horn, 1991; Thier, Axmann, & Giedke, 1986), but suggest that the PINV may not be specific to aversive stimuli. This study provided some insight into the functional significance of the PINV. Nonetheless, no study to date has determined whether it is possible to elicit a PINV with negative and neutral pictures.

A handful of studies (Diener, Struve, Balz, et al., 2009; Diener, Struve, Brusniak, et al., 2009) have examined how prior experiences of control and uncontrollability can affect subsequent processing of these conditions. A recent study (Diener, Struve, Balz, et al., 2009) used tones of differing durations and aversive electrical stimulation to assess the effects of previous stressor uncontrollability in a situation where control was objectively re-established. It was determined that uncontrollable stress (i.e., no control blocks in an S1-S2 paradigm) significantly enhanced PINV magnitudes independent of preceding control, while control over aversive stimulation *prior* to loss of control normalized PINVs during restitution of control. In contrast, another study using aversive electrical stimulation (Diener, Struve, Brusniak, et al., 2009) discovered that enhanced PINV magnitudes were found during an unexpected change from a control condition to a no control condition. This suggests that there are some conflicting findings in the literature concerning PINV magnitudes with initial experiences of control. However, no work has yet examined how prior experiences of controllability may affect neural response to uncontrollable negative and neutral pictures.

The current study set out to determine a) whether it would be possible to elicit a PINV in response to negative and neutral pictures, b) how the LPP elicited by S1 is affected by shifts in control and c) how prior experiences of controllability over negative and neutral pictures would influence subsequent exposure to these stimuli. The study is unique in its combined use of the

LPP and PINV ERP components to investigate stressor uncontrollability with negative and neutral stimuli. Consistent with prior work (Diener et al., 2009; Babkirk, Rios, & Dennis, 2014; Foti et al., 2009), participants were expected to have largest PINV magnitudes during experiences of uncontrollability, and negative pictures were expected to elicit larger LPPs than neutral pictures.

CHAPTER II

METHODS

Participants

Forty-eight undergraduate students, (28 female; age *M* = 19.98, *SD* = 1.42; 77% White [63% Non Hispanic], 10% other, 8% Black, 2% Asian, 2% American Indian/Alaska Native) participated in this experiment for course credit. They received six credits in the TAMU Psychology SONA System for a three-hour session. Written informed consent was obtained from all participants. Subjects were informed that the goal of the study was to measure EEG, but were unaware of the specific experimental procedures and hypotheses. Subjects were randomly assigned to two experimental groups.

Stimuli

Images were drawn from the International Affective Picture System (IAPS; Lang, P. J., 2005). Numerical scales were used for rating control and mood, ranging from 1 (least in control, least negative) to 5 (extremely in control, extremely negative). There were 72 negative and 72 neutral images; the task was presented using Presentation Software.

Experimental Procedure and Task

After giving their consent to participate in the experiment, participants began by completing a demographic form. Next, they were instructed in and completed 10 practice trials before the task began. They performed the IAPS task (Figure 1) while continuous EEG was recorded.

The experimental procedure consisted of a forewarned (S1-S2) reaction paradigm. It was adapted from the task in a previous study (Diener, Struve, Balz, Kuehner, & Flor, 2009), but operationalized through negative and neutral pictures. Participants passively viewed a negative

or neutral picture surrounded by a red border (S1); following S2 onset (same picture, green border), they could push the right or left mouse button to make the picture disappear. The correct mouse button was counterbalanced across the control blocks, which participants were not aware of. There were three different block types; Control Block 1 (C1), Control Block 2 (C2), and No Control Block (NC). Participants were not informed about the different conditions.

During control blocks, participants had control over the stimulus; they could make the picture leave the screen by pushing the left or right mouse button for up to 3000 ms, as told in the initial instructions. During the No Control block, participants did not have control over the stimulus; the picture would stay on screen for a fixed time regardless of the mouse button being pushed, despite being told in the instructions otherwise. Participants were instructed to look at the images the entire time they were on screen.

There were three blocks of 48 trials (one no control, two control blocks). Each trial had a random order of negative (n=24) and neutral (n=24) pictures. Participants were randomly assigned to two groups (Version 1, Version 2) with different block orders. Participants in Version 1 (n=23) experienced uncontrollability, followed by two control blocks. Version 2 (n=25) experienced controllability, followed by loss of control and then resumption of control. Each trial began with a white fixation cross presented in the center of a black background for approximately 2000-2500 ms. Next, the white fixation cross was replaced by a negative or neutral image surrounded by a red border for 1000 ms (S1). The same negative or neutral image surrounded by a green border followed (S2), and the time it stayed on screen varied depending on block type. For the blocks without control, the image surrounded by the green border stayed on screen for 500 or 3000 ms, the order of which was randomized. For the blocks with control, the image left the screen immediately once the correct mouse button was pushed; if it was not

pushed, the image stayed for 3000 ms. At the end of each block, participants rated their level of control and mood, using a 5-point scale; participants had an unlimited response time to make these ratings. Participants were told that after the offset of the rating scales, they would receive a break and should press the spacebar when ready to start the next round of trials.

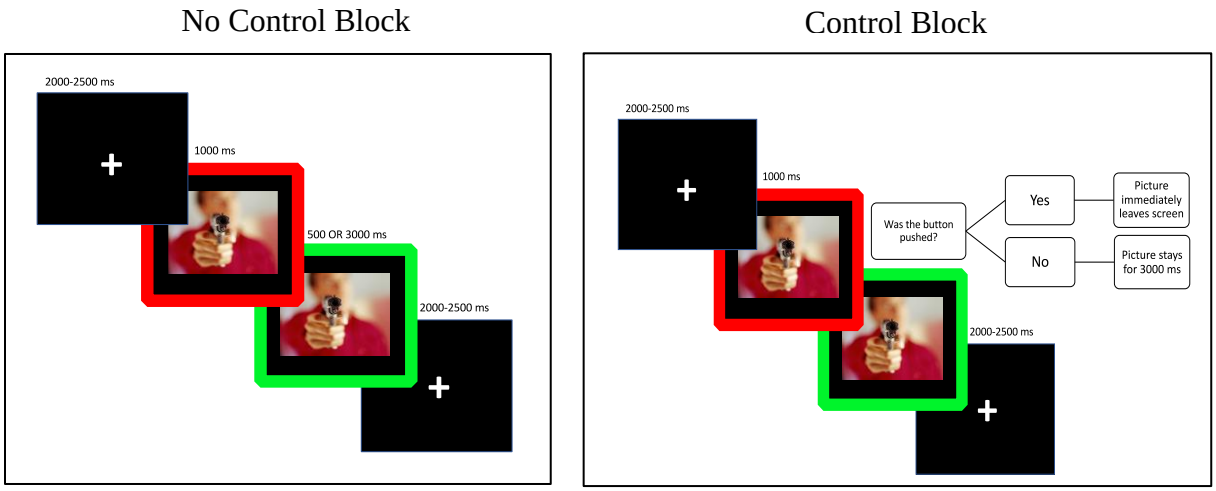

Figure 1. Task Figure**.** Participants passively viewed a negative or neutral picture (S1); following S2 onset (same picture, different border) they were told they could push a button to make the picture disappear, which was true for control blocks and untrue for no control blocks. Only negative pictures are shown, but all block types contained both neutral and negative pictures. At the end of each block of pictures, participants made mood and control ratings.

EEG Recording and Data Reduction

Continuous EEG recordings were collected using an ActiCap and the ActiCHamp amplifier system (Brain Products GmbH, Gilching Germany). Thirty-two electrode sites were used based on the 10/20 system. Electrodes filled with adhesive gel were used. The electrooculogram (EOG) was recorded from four facial electrodes: two that were placed approximately 1 cm above and below the right eye, forming a bipolar channel to measure vertical eye movement and blinks and two that were placed approximately 1 cm beyond the outer edges of each eye, forming a bipolar channel to measure horizontal eye movements. The EEG data were digitized at 24-bit resolution and a sampling rate of 500 Hz.

The EEG data was processed using Brain Vision Analyzer 2 software (Brain Products GmbH, Gilching Germany). Data were segmented for each trial beginning 200 ms prior to the task onset and continuing for 3200 ms, and re-referenced offline to the average FP1 and FP2. The eye blink and ocular correction method used was developed by Miller, Gratton and Yee (1988). Trials were visually examined for remaining artifacts, and the data from individual channels containing artifacts were rejected on a trial-to-trial basis. Baseline correction for each trial was performed using average amplitudes in the period from 200-0 ms prior to S1 for the LPP. For the PINV, baseline correction for each trial was performed using the 200-0 ms period prior to S2 onset (i.e., 800-1000 ms following S1 onset).

The LPP was scored by averaging amplitudes at pooling, CP1, CP2, and Pz. The PINV was scored by averaging amplitudes at pooling, FP1 and FP2. Based on previous research (Kathmann, Jonitz, & Engel, 1990; MacNamara, Post, Kennedy, Rabinak, & Phan, 2013) PINV and LPP magnitudes were expected to be largest at these sites. The LPP was quantified using the 400-1,000 ms time window. The PINV was quantified using two time windows: 400-800 ms and 1,000-2,000 ms post-S2 onset.

Statistical Analysis

The PINV and LPP were analyzed using a 3 (Block: no control, control 1, control 2) X 2 (Picture Type: negative, neutral) X 2 (Group: version 1, version 2) mixed between and within subjects repeated measures analysis of variance (ANOVA). Behavioral data (percent of trials on which participants pressed the correct button) were analyzed using a 2 (Block: control 1, control 2) X 2 (Picture Type negative, neutral) X 2 (Group: version 1, version 2) mixed between and within subjects repeated measures ANOVA. Ratings were analyzed using a 2 (Block: control 1, control 2) X 2 (Group: version 1, version 2) mixed between and within-subjects repeated

measures analysis of variance (ANOVA). Significant interactions were followed up using ANOVAs and *t*-tests as appropriate. Greenhouse-Geisser correction was used for violation of sphericity as needed. All analyses were performed using SPSS statistical software version 22.0 (IBM, Armonk, NY).

CHAPTER III

RESULTS

TABLE 1. Means (*SDs*) for ERP μV, percent correct, and control ratings.

ERPs, Accuracy, Control Ratings	Version	NC		C1		C2	
Picture Type		Neutral	Negative	Neutral	Negative	Neutral	Negative
LPP μV (400-1000 ms)	1	2.35 (5.09)	4.51 (5.94)	-2.12 (5.36)	6.22 (7.89)	1.02 (4.87)	5.17 (5.84)
	2	1.51 (3.20)	4.16 (4.28)	-2.37 (3.68)	2.55 (4.06)	-1.52 (4.04)	4.91 (5.05)
PINV μV (400-800 ms)	1	3.22 (4.25)	3.11 (5.42)	5.62 (7.94)	5.70 (5.37)	4.87 (4.20)	4.76 (5.70)
	2	2.98 (4.68)	3.50 (4.32)	5.31 (3.50)	4.77 (6.13)	4.95 (5.32)	5.26 (4.96)
PINV μV (1000-2000 ms)	1	3.84 (4.00)	3.42 (4.61)	6.79 (10.05)	4.84 (5.08)	4.86 (4.25)	3.72 (6.00)
	2	5.10 (6.93)	4.23 (5.86)	7.42 (8.07)	7.38 (8.53)	5.21 (6.62)	4.93 (7.20)
% Correct	1	*n/a*		77.00% (28.73)	83.33% (18.03)	57.07% (43.09)	65.76% (41.53)
	2			78.83% (31.46)	82.17% (31.29)	32.50% (42.25)	46.33% (43.79)
		NC		C1		C2	
Control Ratings	1	2.52 (1.12)		3.74 (1.21)		3.39 (1.34)	
	2	2.40 (1.41)		3.04 (1.51)		2.80 (1.50)	

Ratings

For control ratings, there was a significant main effect of block, $F(1, 47) = 11.20$, $p = .00$, $n_p^2 = .20$, such that participants reported feeling less control during NC ($M = 2.46$, $SD = 1.27$)

compared to C1 ($t(47) = 4.82$, $p = .00$; $M = 3.38$, $SD = 1.41$) and compared to C2 ($t(47) = 3.57$, $p = .001$; $M = 3.08$, $SD = 1.44$). The block type x group interaction did not reach significance ($p = .32$). There were not significant differences for the mood ratings (all ps > .15).

Behavior

There was a significant main effect of block, $F(1, 47) = 22.67$, $p = .00$, $n_p^2 = .33$ for number of correct responses. Participants had a higher percent correct for C1 ($M = .80$, $SD = .28$) compared to C2 ($M = .50$, $SD = .44$). Additionally, there was a main effect for picture type, $F(1, 47) = 7.61$, $p = .008$, $n_p^2 = .14$ such that participants had a higher percent correct for negative ($M = .69$, $SD = .35$) compared to neutral images ($M = .61$, $SD = .37$). No other main effects or interactions reached our threshold for significance (all ps > .05).

Late Positive Potential

Figure 2 depicts grand-averaged waveforms at CP1, CP2, and Pz, shown separately for the two participant groups (Version 1, Version 2), as well as scalp distributions showing the difference between C2 minus C1, NC minus C1, and negative minus neutral images shown separately for the two participant groups. Of note, more positive amplitudes are plotted downwards. Statistical analyses revealed a block type x group interaction, $F(2, 47) = 2.94$, $p = .05$, $n_p^2 = .04$. Follow-up tests showed that the effect of block type was specific to Version 2, the group that started with control, $F(2, 47) = 5.81$, $p = .006$, $n_p^2 = .20$; Version 1 $p = .39$. A paired samples t-test revealed that among participants who started with control, the LPP was larger for both blocks following the initial block: NC > C1 ($t(47) = 2.78$, $p = .011$; NC, $M = 1.33$, $SD = 3.24$; C1, $M = 0.09$, $SD = 3.50$) and C2 > C1 ($t(47) = 2.88$, $p = .008$; C2, $M = 1.69$, $SD = 4.11$) . Additionally, the LPP was larger for negative compared to neutral pictures, $F(1, 47) = 158.17$, p

= .00, n_p^2 = .78; Negative, *M* = 4.56, *SD* = 5.63; Neutral, *M* = -1.81, *SD* =4.37). No other main effects or interactions reached our threshold for significance (all *p*s > .05).

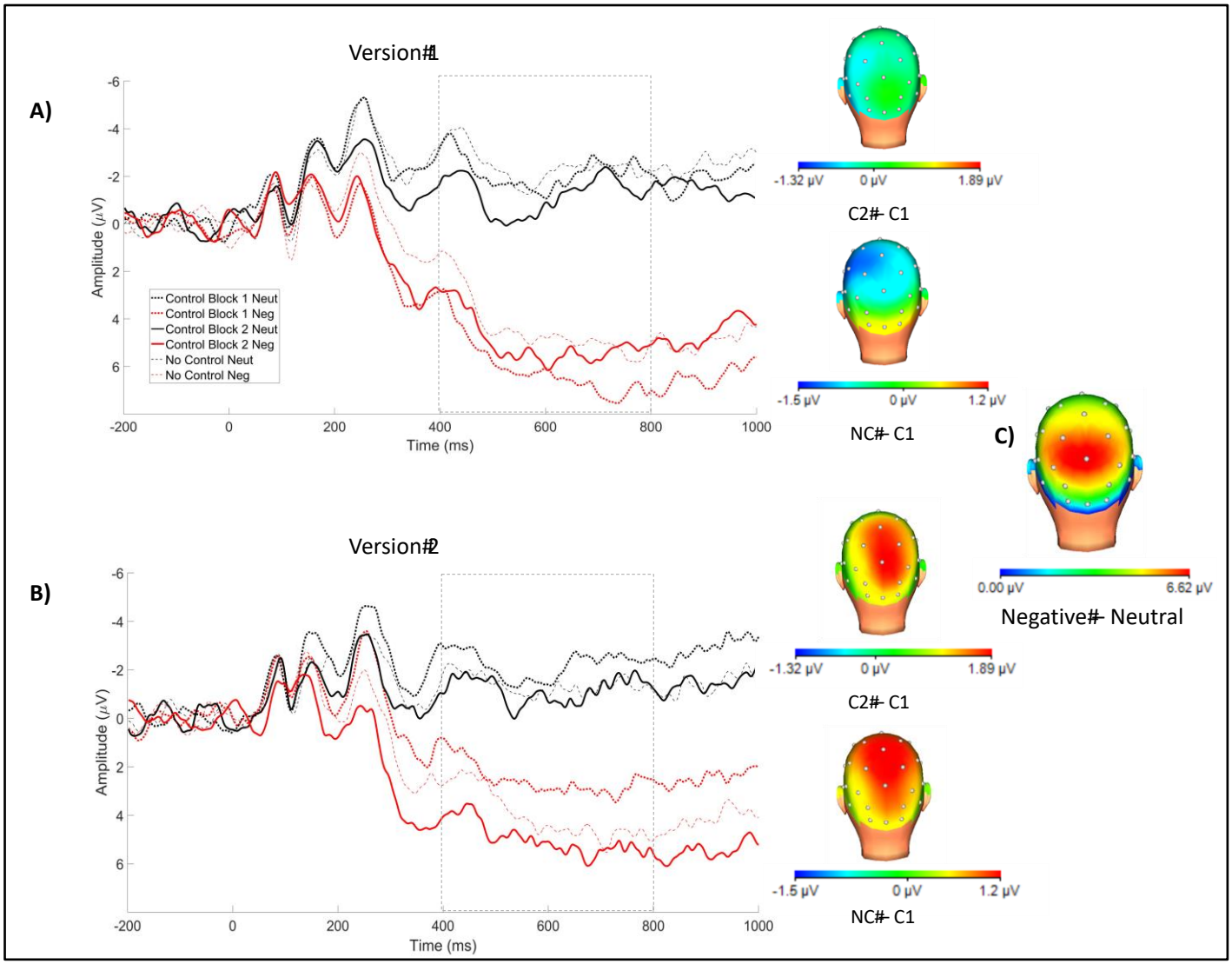

FIGURE 2. The LPP. A) Version 1 grand average waveforms at a pooling of CP1, CP2 and Pz, and scalp distributions of the C2 minus C1 & NC minus C1 differences, B) Version 2 grand average waveforms at a pooling of CP1, CP2, and Pz, and scalp distributions of the C2 minus C1 & NC minus C1 differences, C) scalp distribution of the Negative minus Neutral difference across both Version 1 and 2.

Post Imperative Negative Variation

Figure 3 depicts grand-averaged wave forms at Fp1 and Fp2, shown separately for two time windows: 400-800 ms (top) and 1,000-2,000 ms (bottom), as well as scalp distributions showing the differences between NC minus C1 and NC minus C2 for the early window, and C2 minus C1 and NC minus C2 for the late window. Of note, more positive amplitudes are plotted downwards. Additionally, because the PINV is a negative-going component, more *negative* amplitudes mean *larger* PINVs.

400-800 ms

There was a main effect of block type for the early time window, $F(2, 47) = 7.31$, $p = .001$, $n_p^2 = .14$. Follow up paired samples *t*-tests showed that NC ($M = 3.21$, $SD = 3.90$) elicited a larger PINV than C1 ($t(47) = 3.81$, $p = .00$; $M = 5.34$, $SD = 5.00$) and C2 ($t(47) = 2.77$, $p = .008$; $M = 4.97$, $SD = 4.45$). No other main effects or interactions reached our threshold for significance (all *p*s > .60).

1000-2000 ms

There was also a main effect of block type for the late time window, $F(2, 47) = 6.21$, $p = .003$, $n_p^2 = .12$. Follow up paired samples *t*-tests revealed that there was a larger PINV for NC ($M = 4.17$, $SD = 4.63$) than C1 ($t(47) = 3.27$, $p = .002$; $M = 6.64$, $SD = 6.98$), and that C2 ($M = 4.70$, $SD = 5.23$) elicited a larger PINV than C1 ($t(47) = 3.05$, $p = .004$; $M = 6.64$, $SD = 6.98$). No other main effects or interactions reached our threshold for significance (all *p*s > .20).

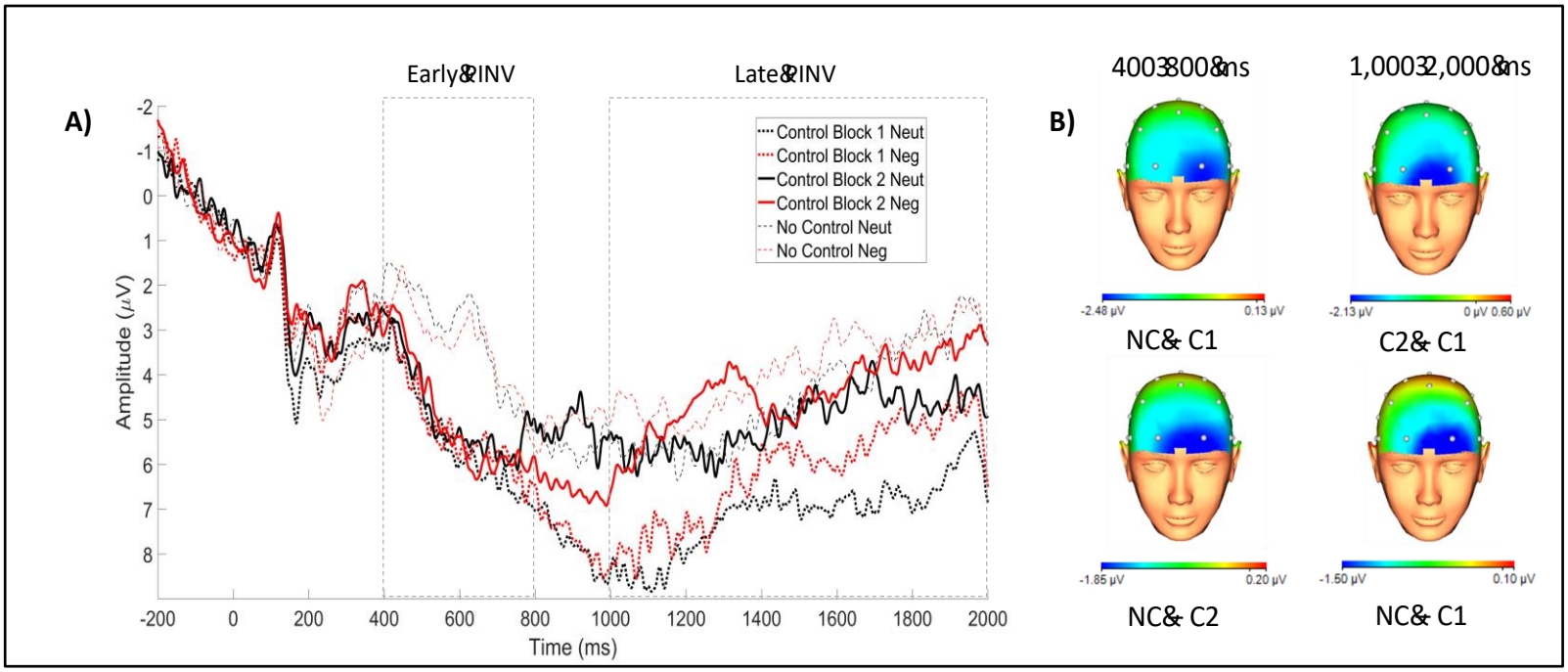

FIGURE 3. The PINV. A) Grand average wave forms at a pooling of FP1 and FP2, time-locked to S2 onset (at time 0) and shown for all conditions. B) Scalp distributions of the NC minus C1 & NC minus C2 differences for the early window (left) and the C2 minus C1 & NC minus C1 differences for the late window (right).

CHAPTER IV

DISCUSSION

This study assessed the effects of stressor controllability and uncontrollability over negative and neutral pictures in an unselected sample. While previous studies have successfully modulated stressor controllability through means of change from a condition of control to loss of control and vice versa in reaction (S1–S2) paradigms (Rockstroh et al. 1979; Diener et al., 2009), we expanded the scope of the study through the addition of negative and neutral images.

One major objective of the study was to assess how the LPP to S1 was affected by shifts in control. Results showed that among participants who started with control, loss of control increased the LPP and this effect persisted even after restitution of control. This suggests that in assessing motivated attention towards emotional stimuli, prior control *does* matter. It might also demonstrate that uncontrollability leads to increases in motivated picture processing.

Another important goal of the study was to investigate PINV magnitudes in response to conditions of controllability compared to uncontrollability. It was revealed that during early onset of S2, the NC Block elicited larger PINVs than both control blocks, whereas later in S2, both NC and C2 had larger magnitudes than C1. This may indicate a functional difference between the early and late PINV. The early PINV may be especially sensitive to *uncontrollability*, whereas the late PINV may reflect more elaborated processing of *changes* in stimulus controllability.

The study also examined how PINV magnitudes were affected by prior experiences of controllability and uncontrollability over negative and neutral pictures. There are contradictory results in the literature regarding initial experiences of control and its influence on subsequent exposure to aversive stimuli. One study (Diener, Struve, Brusniak, Kuehner, & Flor, 2009)

determined that enhanced PINV magnitudes were found during an unexpected shift from a control condition to a no control condition. In contrast, a similar study (Diener, Struve, Balz, Kuehner, & Flor, 2009) found that uncontrollable stress enhanced PINV magnitudes *independent* of preceding control, while control over aversive stimuli *prior* to loss of control normalized PINVs during restitution of control. Our work did not find evidence of such an effect; results suggest that early PINV magnitudes are largest for experiences without control, regardless of any initial experiences of prior control. This could be due to the small sample size, indicating low statistical power. There were also no significant differences elicited for picture type, which is in line with the finding that the PINV may not be specific to aversive or emotional stimuli (Casement et. al., 2008).

Our study had several limitations. The sample size was probably not large enough to identify higher-order interactions (e.g. between group and block or group and picture type) with sufficient statistical power. Additionally, the functional significance of the PINV is not universally agreed upon. For example, an enhanced PINV has also been observed in schizophrenic patients where it is considered an indicator of task-related ambiguity (Klein, Rockstroh, Cohen, Berg, & Dressel, 1996; Verleger, Wascher, Arolt, Daase, Strohm, & Kompf, 1999).

In conclusion, while the PINV has been established as a reliable indicator of loss of or shifts in control in previous work using aversive tones and electrical stimulation (Rockstroh et al. 1979; Bolz & Giedke, 1981; Kathmann et al. 1990), this is the first study to show that it can be elicited via control/uncontrollability of negative and neutral pictures. In addition, the study yielded evidence of an early and late PINV that may be functionally distinct. Moreover, while the LPP is known to be a consistent measure of emotional picture processing during S1,

(Horndasch, Heinrich, Kratz, & Moll, 2012) this study revealed that among those with a contingent response-outcome history, uncontrollable stress may lead to persistent increases in motivated picture processing.

REFERENCES

Breier, A. (1989). Experimental approaches to human stress research: assessment of neurobiological mechanisms of stress in volunteers and psychiatric patients. *Biological Psychiatry*, *26*(3), 438–462.

Maier, S. F., & Watkins, L. R. (2005). Stressor controllability and learned helplessness: The roles of the dorsal raphe nucleus, serotonin, and corticotropin-releasing factor. *Neuroscience And Biobehavioral Reviews*, *29*(4-5), 829-841.

Simson, P. G., Weiss, J. M., Hoffman, L. J., & Ambrose, M. J. (1986). Reversal of behavioral depression by infusion of an alpha-2 adrenergic agonist into the locus coeruleus. *Neuropharmacology*, *25*(4), 385-389.

Diener, C., Struve, M., Balz, N., Kuehner, C., & Flor, H. (2009). Exposure to uncontrollable stress and the postimperative negative variation (PINV): Prior control matters. *Biological Psychology*, *80*(2), 189-195.

Blackwood, D. H., & Muir, W. J. (1990). Cognitive brain potentials and their application. *The British Journal Of Psychiatry*, *157*(9), 96-101.

Elbert, T., Rockstroh, B., Lutzenberger, W., Birbaumer, N. (1982). Slow brain potentials after withdrawal of control. *Archiv für Psychiatrie und Nervenkrankheiten*, *232*(7), 201–214.

Rockstroh, B., Elbert, T., Lutzenberger, W., & Birbaumer, N. (1979). Slow cortical potentials under conditions of uncontrollability. *Psychophysiology*, *16*(4), 374-380.

Kathmann, N., Jonitz, L., & Engel, R. R. (1990). Cognitive determinants of the postimperative negative variation. *Psychophysiology*, *27*(3), 256-263.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology*, *52*(2), 95-111.

Foti, D., Hajcak, G., & Dien, J. (2009). Differentiating neural responses to emotional pictures: Evidence from temporal-spatial PCA. *Psychophysiology*, *46*(3), 521-530.

Hajcak, G., MacNamara, A., & Olvet, D. M. (2010). Event-related potentials, emotion, and emotion regulation: An integrative review. *Developmental Neuropsychology, 35*(2), 129-155.

Diener, C., Kuehner, C., Brusniak, W., Struve, M., & Flor, H. (2009). Effects of stressor controllability on psychophysiological, cognitive and behavioural responses in patients with major depression and dysthymia. *Psychological Medicine, 39*(1), 77-86.

Casement, M. D., Shestyuk, A. Y., Best, J. L., Casas, B. R., Glezer, A., Segundo, M. A., & Deldin, P. J. (2008). Anticipation of affect in dysthymia: Behavioral and neurophysiological indicators. *Biological Psychology, 77*(2), 197-204.

Kessler, M., Munz, D., & Traue, H. C. (1992). Psychophysiological responses in neurotic depression. *Journal Of Psychophysiology, 6*(4), 333-344.

Knott, V. J., Lapierre, Y. D., De Lugt, D., Griffiths, L., Bakish, D., Browne, M., & Horn, E. (1991). Preparatory brain potentials in major depressive disorder. *Progress In Neuro-Psychopharmacology & Biological Psychiatry, 15*(2), 257-262.

Thier, P., Axmann, D., & Giedke, H. (1986). Slow brain potentials and psychomotor retardation in depression. *Electroencephalography & Clinical Neurophysiology, 63*(6), 570-581.

Babkirk, S., Rios, V., & Dennis, T. A. (2015). The late positive potential predicts emotion regulation strategy use in school-aged children concurrently and two years later. *Developmental Science, 18*(5), 832-841.

Klein, C., Rockstroh, B., Cohen, R., Berg, P., & Dressel, M. (1996). The impact of performance uncertainty on the postimperative negative variation. *Psychophysiology, 33*(4), 426-433.

Verleger, R., Wascher, E., Arolt, V., Daase, C., Strohm, A., & Kömpf, D. (1999). Slow EEG potentials (contingent negative variation and post-imperative negative variation) in schizophrenia: Their association to the present state and to Parkinsonian medication effects. *Clinical Neurophysiology, 110*(7), 1175-1192.

Bolz, J., & Giedke, H. (1981). Controllability of an aversive stimulus in depressed patients and healthy controls: A study using slow brain potentials. *Biological Psychiatry, 16*(5), 441-452.

Kathmann, N., Jonitz, L., & Engel, R. R. (1990). Cognitive determinants of the postimperative negative variation. *Psychophysiology*, *27*(3), 256-263.

MacNamara, A., Post, D., Kennedy, A. E., Rabinak, C. A., & Phan, K. L. (2013). Electrocortical processing of social signals of threat in combat-related post-traumatic stress disorder. *Biological Psychology*, *94*(2), 441-449.

Horndasch, S., Heinrich, H., Kratz, O., & Moll, G. H. (2012). The late positive potential as a marker of motivated attention to underweight bodies in girls with anorexia nervosa. *Journal Of Psychosomatic Research*, *73*(6), 443-447.