HIGH APPROACH-MOTIVATED

NEGATIVE AFFECT ENHANCES THE

REWARD POSITIVITY

by

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ABSTRACT

Past work has demonstrated that the reward positivity (RewP) reflects a binary evaluation of good versus bad outcomes. Recent studies have suggested that the RewP may be sensitive to approach-motivated states prior to goal pursuit. However, previous research has not investigated whether the modulation of the RewP is due to affective valence or motivational state. In order to disentangle the impact of affective valence and motivation on the RewP, I investigated whether anger, a negative affect state high in approach-motivation, transmogrified the RewP. First, participants received insulting feedback on an essay written by the participant from an ostensible opponent. Then, participants completed a revised monetary incentive delay task. In the task, cues evoked an approach-motivated pregoal (reward trials), neutral, or withdrawal-motivated pregoal (punishment trials) states. Next, participants competed in a reaction time game against the opponent. Postgoal cues indicated the outcome of the game (win vs. loss). Following the postgual cues, participants had the opportunity to aggress against the other opponent by delivering a noise blast (reward trials), perform no action (neutral trials), or receive a noise blast from the other participant (punishment trials). Results revealed that win feedback in reward trials elicited a larger RewP than win feedback in neutral trials. Additionally, the RewP was larger following win feedback in reward trials than loss feedback in reward trials. Interestingly, feedback in punishment trials elicited a larger RewP than feedback in neutral trials, but failed to differentiate between win and loss feedback in punishment trials. Finally, the predicted relationship between greater aggression towards the offending individual and larger RewP amplitudes after reward trial wins did not occur. These results indicate that negative affects high

in approach motivational intensity enhance the RewP. This likely occurs because approach motivation enhances feedback processing, regardless of whether the motivation was a result of positive or negative states.

DEDICATION

This thesis is dedicated to my wife, Meghan Threadgill, and my ever-supportive family. Your never-ending love has supported me throughout this entire journey.

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of variance
dB	Decibel
EEG	Electroencephalography
ERP	Event-related brain potential
e.g.	Exempli gratia or “for example”
et al.	Et alii or “and others”
etc.	Et cetera or “and the rest”
fMRI	Functional magnetic resonance imaging
Hz	Hertz
i.e.	Id est or “that is”
ISI	Interstimulus interval
ITI	Intertrial interval
MID	Monetary incentive delay
ms	Milliseconds
RewP	Reward positivity
s	Seconds
vs.	Versus
UA	University of Alabama
F	Fisher’s F ratio: A ratio of two variances
n	Sample size of group

p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
r	Pearson product-moment correlation
<	Less than
=	Equal to
η_p^2	Partial eta squared effect size measure

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Affective states have an important impact on goal pursuit and attainment. Much work on goal pursuit has examined the impact of emotion on a variety of dimensions. One dimension of emotion is that of affective valence, or whether an emotion is pleasant or unpleasant. Another dimension of emotion is motivational direction, or the propensity to approach towards or withdraw from an object. Approach motivation refers to an action tendency to move towards an object, while withdrawal motivation refers to an action tendency to draw away from an object. Additionally, approach- and withdrawal-motivated affects vary in their intensity. Motivational intensity denotes the amount of motivation inherent within an affect. Within a given motivational direction, motivational intensity can range from high to low. For example, desire and anger are both higher in approach motivational intensity than contentment and sadness.

High and low approach-motivated affects occur at different stages of goal pursuit. High approach-motivated states are preparatory states that facilitate goal pursuit, where an organism is actively preparing or attempting to obtain some reward and is motivated to work towards that goal (Gable & Harmon-Jones, 2008, 2010a; Hart & Gable, 2013). For example, past research has shown that high approach-motivated positive affect evokes neural activity associated with motor-action preparation (Gable, Threadgill, & Adams, 2016), as well as more successful goal pursuit (Hart & Gable, 2013). In contrast, low approach-motivated affective states reflect assessments of whether goal attainment or failure has occurred (Kaplan, Van Damme, & Levine, 2012). Approach motivation facilitates action monitoring to inform the individual to either follow the present course of action towards the goal or adjust behaviors to increase the chance of attaining the goal (Levine & Edelstein, 2009). The present work seeks to understand the influence of negative approach-motivated states on the neural underpinnings of goal-related outcome monitoring.

The Reward Positivity

Integral to goal pursuit is feedback signaling the success or failure of actions during goal pursuit. Attention to feedback relates to performance monitoring and serves to inform individuals whether actions were successful or unsuccessful. Action monitoring is enhanced for processing rewarding feedback in order to maximize the probability of successfully attaining future rewards (Sutton & Barto, 1998). The reward positivity (RewP) is an ERP component thought to reflect the evaluation of performance feedback and action monitoring (Proudfit, 2015). Traditionally known as the feedback negativity, this ERP component is an underlying positive-going deflection occurring in the time range of 250-350 ms at frontocentral sites. Past work has argued that the RewP reflects a reinforcement learning model intricately related to the error-related negativity (Miltner, Braun, & Coles, 1997). Feedback-related information is used to determine whether or not an error has been committed, and future behavior is adjusted based upon these evaluations (Holroyd & Coles, 2002). However, more recent work suggests that the RewP reflects a binary evaluation of reward feedback as either good or bad, sensitive to rewarding stimuli as opposed to non-rewarding stimuli (Hajcak, Moser, Holroyd, & Simons, 2006; Proudfit, 2015). Thus, positive feedback evokes a larger positive-going wave than negative or neutral feedback (Holroyd, Hajcak, & Larsen, 2006; Holroyd, Krigolson, & Lee, 2011; Weinberg, Riesel, & Proudfit, 2014).

It is likely that multiple neural generators produce the RewP. Some research using source localization techniques has shown that the RewP is potentially generated by the anterior cingulate cortex (Gehring & Willoughby, 2002; Hauser et al., 2014; Holroyd & Coles, 2002), while others have suggested that the RewP is generated by the striatum and medial prefrontal cortex using source localization (Foti, Weinberg, Dien, & Hajcak, 2011) and EEG/fMRI research (Carlson, Foti, Mujica-Parodi, Harmon-Jones, & Hajcak, 2011; Carlson, Foti, Harmon-Jones, & Proudfit, 2014). Additionally, the RewP is influenced by the mesocorticolimbic dopamine system, a neural network associated with reward processing (Carlson et al. 2011; Santesso et al., 2008). Research on the RewP has been further examined using time-frequency analyses, finding increases in the delta frequency band following win feedback and increases in the theta band following loss feedback (Bernat, Nelson, & Baskin-Sommers, 2015; Bernat, Nelson, Steele, Gehring, & Patrick, 2011).

The Reward Positivity and Motivation

The RewP appears to be influenced by both affective and motivational variables. For instance, states and traits related to negative affect low in motivational intensity have been associated with a decrease in the magnitude of the RewP. Notably, Foti & Hajcak (2009) found that greater levels of depression was negatively correlated with smaller RewP amplitudes. Similarly, participants who reported greater levels of sadness during post-induction mood ratings showed smaller RewPs (Foti & Hajcak, 2010).

In contrast, the RewP has been positively associated with greater high approach-motivated positive affect. For example, greater trait approach-motivation measured using Carver and White’s (1994) Behavioral Activation Scale correlates with larger RewPs in gambling tasks (Lange, Leue, & Beauducel, 2012). Larger RewPs have also been linked with measures of reward responsiveness (Bress & Hajcak, 2013), liking of desirable rewards (Angus, Kemkes, Schutter, & Harmon-Jones, 2015), and degree of perceived agency in obtaining awards (Yeung, Holroyd, & Cohen, 2005), all have been associated with approach motivation. Likewise, Threadgill & Gable (2016) found that high approach-motivated pregoal positive states elicited a larger RewP than neutral states. Additionally, reward trials evoked a larger RewP than neutral trials, regardless of the outcome. Furthermore, larger RewPs in approach-motivated pregoal positive states correlated with better performance (i.e., faster reaction times) on the goal-related task (Threadgill & Gable, 2016). In sum, the RewP appears to be larger following approach-motivated pre-goal states. Approach motivation appears to likely enhance performance monitoring during goal pursuit.

Anger and the Reward Positivity

Previous research investigating the RewP has mostly examined how the RewP is influenced by positive or negative states, leaving the relationship between valence, motivational direction, and the RewP unexplored. However, because of the relationship between RewP amplitude and positive approach-motivated affects, it may be the case that rewarding feedback for goals spurred by negative states high in approach-motivation elicit a larger RewP than rewarding feedback in neutral states. Anger is a negative state originating from the blockage of movement toward a desired goal (Berkowitz, 1989). It is associated with approach motivation when individuals are able to engage with the offending object, bringing the anger-producing event to resolution (Carver & Harmon-Jones, 2009). Because anger is associated with approach motivation, and approach-motivated states have been found to impact the RewP, anger may impact the RewP when approach-related action is possible.

Previous research examining the relationship between the RewP and anger has suggested that there may be a relationship. Angus et al. (2015) found that, after an anger induction, larger RewPs were associated with greater subjective liking for rewards. Additionally, larger RewPs were associated with greater perceived control over attaining the prize. These findings point to the possibility that high approach-motivated negative states may influence the amplitude of the RewP. However, their results did not find a difference between the anger and neutral conditions.

This may have occurred because the study design may not have been well-suited to detect the impact of approach-motivated anger on the RewP. They manipulated anger by having participants write about an emotional event in which they felt “very angry,” as well as listen to instrumental music that evokes anger. This may have been problematic, in that anger does not always elicit approach-motivated behaviors. Indeed, in scenarios where there are no available behaviors to deal with the source of the anger, anger elicited neural activity and behaviors associated with withdrawal motivation (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). This suggests that anger is approach-motivated in situations when organisms are given an outlet to resolve the source of anger. Because participants were able to rectify the angering event, participants exhibited neural correlates of approach-motivated affects and engaged in behaviors that would bring about a resolution to the anger-arousing situation. The study design in Angus et al. (2015) did not measure reward processing in relation to the ability to reconcile the source of the approach-motivated anger. It may be the case that anger did not directly impact the magnitude of the RewP because rewards were unrelated to the source of the anger. It may be the case that when anger is able to be redressed, the individual elicits larger RewPs because actions could be taken to emend the problem.

Additionally, past research has shown that approach-motivated positive pregoal states during pursuit of an explicit goal elicit larger RewPs than neutral states upon successfully attaining the goal (Threadgill & Gable, 2016). Weinberg, Riesel, and Proudfit (2014) have also shown that monetary incentives in a gambling task elicit a larger RewP than no monetary incentives. Consequently, it seems that approach-motivated anger may elicit an increased RewP in situations where the angering object can be acted upon. For example, individuals may show enhanced RewPs in anger states when they are able to aggress against a hostile opponent.

The Current Experiment

The aim of my proposed research is to investigate whether anger, a high intensity approach-motivated negative affect, directly impacts the amplitude of the RewP using a combination of an aggression paradigm and a modified monetary incentive delay task (MID). The aggression paradigm is designed to induce approach-motivated anger, giving participants the opportunity to aggress against an opponent who insulted them earlier. The MID task evokes approach-motivated pregoal states by giving individual experiencing anger the opportunity to blast the opponent with a loud noise. Anger is elicited by the receipt of insulting feedback on an essay evaluation. Opportunities to blast one's opponent with noise are based on performance in a reaction time game (e.g., flankers response; Eriksen & Eriksen, 1974). Rewards or losses are indicated in performance-related feedback (Gable & Harmon-Jones, 2010b, 2011; Knutson, Westdorp, Kaiser, & Hommer, 2000; Peterson, Shackman, & Harmon-Jones, 2008). Because the motivation to aggress, brought about anger, is able to be acted upon, the aggression MID paradigm is able to test whether approach-motivated anger evokes a different neural response to reward feedback than a neutral affective state.

Based on past research, I predicted that the RewP would be larger to win feedback than to loss feedback. Also, I predicted that the RewP would be larger to feedback following high intensity approach-motivated goal states (reward trials) than neutral states (neutral trials). Because no research has been conducted examining the relationship between the RewP and high intensity withdrawal-motivated goal states, no a priori predictions were made for the RewP during punishment trials between either win feedback and loss feedback or punishment trials and neutral trials. Finally, because approach-motivated anger is associated with both neurophysiological mechanisms of approach motivation and aggression, I predicted that larger RewP amplitudes to reward trial wins would be associated with greater aggression (as measured by the selection of longer noise blasts) upon winning the opportunity to blast a hostile opponent with a loud noise.

METHODOLOGY

Sixty introductory psychology students participated in exchange for partial course credit. Some have suggested that participants who fail to show psychophysiological markers of the target emotion, measured independently of the main task, should be excluded from analyses, because it is likely that the manipulation failed to elicit the target emotion (Basso, Schefft, & Hoffman, 1994; Shackman et al., 2006; Stemmler, 2003). One psychophysiological marker of increased approach-motivated anger is increased left frontal alpha asymmetry after an anger induction, relative to a baseline (Harmon-Jones & Sigelman, 2001; Jensen-Campbell, Knack, Waldrip, & Campbell, 2007; Verona, Sadeh, & Curtin, 2009). Therefore, I excluded from analyses those participants who failed to show an increase in left frontal alpha activity after the anger induction. Specifically, data from 14 participants failed to show an increase in left frontal alpha asymmetry. Additionally, 2 participants RewP scores were more than 3 standard deviations from the mean and were subsequently excluded. This left 44 participants for hypothesis testing. A priori power analyses using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) determined that this was a sufficient sample size to detect a medium effect size of 0.25, which is consistent with past research.

Participants were brought into the lab alone. Participants were told that they would be taking part in two experiments: the first one was to examine the relationship between personality variables and writing styles, and the second one involved playing a reaction time game against another participant. Experimenters told participants that there was another participant in the room next door with whom they would be interacting. This person did not actually exist. To increase believability, a backpack sat outside of the next room next door, hinting to participants that there really was another participant at the study. Additionally, participants were told that the other participant was instructed to get there 15 minutes before the actual participant, so that both individuals would be unable to form any impressions of the other participant based on the appearance and temperament of the other person. The experimenter gave all instructions as if there were two participants participating in the study (leaving the room to discuss instructions with the other participant, staying outside of the room for a considerable length of time to emulate delivering instructions, etc.). Also, throughout the course of the experiment, experimenters carefully insinuated at the existence of the other participant. Finally, while proceeding through the experiment, participants wore stereo headphones, so that they are unable to hear interactions between the experimenter and the other participant.

After giving consent, participants were told that the first study involved one participant writing an essay, while the other participant evaluated the essay. Participants then drew from a hat to determine who would be the writer and who would be the grader. Both slips of paper in the hat read “writer.” The participant drew first, to make it appear as though they were actually drawing the condition of writer. The experimenter then went into the other room, leaving the other piece of paper on the ground, to appear as if the other participant drew the condition of grader. Participants were then given the “Social Attitudes Assessment.” On it, they were instructed to write an essay defending their position on a controversial issue, picking a subject that is the most important to that individual from a list of controversial topics. Examples include reducing the drinking age, the legality of homosexual marriage, and the legality of abortion. After 10 minutes, the experimenter stopped the participant, who then took it to the other “participant” to be graded.

After “delivering” the essay, the participant the completed a variety of personality surveys that the “grader” had ostensibly completed during the writing phase. The first question asked, on a scale of 1 (*Not important*) to 9 (*Extremely important*), how important to the participant was the topic that they wrote about. Once the participant has finished filling out the personality questionnaires, the experimenter applied EEG sensors, and recorded 4 minutes of resting EEG activity.

The experimenter then went back into the participant room, presumably to set up for the next experiment. While the experimenter was setting up the next experiment (i.e., turning on computer monitors, making sure speakers were at the correct volume, etc.), the experimenter offhandedly mentioned to the participant that they can see the feedback that the other participant gave them if they wished. The experimenter then handed the participant an envelope containing an evaluation sheet with feedback written on it. After handing the participant the feedback, the experimenter then excused themselves to go check on the other participant (who was ostensibly finishing up the resting baseline EEG measurements), letting the participant know that they would be back in a few minutes to explain the second experiment.

The feedback was designed to be relatively negative. The feedback consisted of ratings on several different categories, allegedly given by the other participant. Participants saw ratings on a 9-point bipolar scale on the following characteristics: unintelligent—intelligent, thought-provoking—boring, friendly—unfriendly, illogical—logical, respectable—unrespectable, and irrational—rational. The evaluation consisted of ratings of 2 or 3 when negative words represent a 1, and 7 or 8 when negative words represent a 9. At the bottom of the page, the other participant ostensibly wrote, “I can’t believe an educated person would think like this. I hope this person learns something while at UA [University of Alabama]!” Additionally, the experimenter wrote in additional negative feedback, referring directly to the issue that the participant wrote about. The experimenter wrote, "I can't even believe that they would think that [issue] should be [allowed/not allowed]!" Pilot testing indicated that this negative feedback increased anger, frustration, and hostility relative to baseline levels at the beginning of the experiment.

Once the participant has finished reading the feedback, the experimenter told the participant that they needed to take a second baseline recording while they were waiting on the other participant to finish their baseline recordings. Participants were instructed to think about how they presently felt. At this point, an additional 1 minute of EEG data was recorded.

After the second baseline recording, the experimenter returned to the experiment room and explained the second study. Participants were told that they would be competing against the other participant in a reaction time game. They were told that the computers were connected in real time through cables in the back of the room, and all feedback was dependent on which participant was quicker to respond correctly. The experimenter told the participant that the game would begin once they had given the other participant the instructions. The experimenter left the room, waited for 30 s, and started the game. Instructions for the game were presented on the computer.

The game was modeled after previous research on aggression (Taylor, 1966; Bartholow & Anderson, 2002; Peterson et al., 2008), in which participants were given the opportunity to blast the other participant with noise if they were faster than their opponent in a reaction time game. Each trial (n = 72; see Figure 1) began with a trial cue displayed in the center of a computer monitor, consisting of one of the following shapes: a white circle, a white triangle, or a white square. Circles represented reward trial cues, indicating participants had the opportunity to win the ability to blast their opponent with noise based on their trial performance. Triangles represented neutral trials, indicating that no reward could be won for winning a trial. Squares represented punishment trial cues, indicating that their opponent could win the opportunity to blast the participant with noise on the trial. One-third of the trials were reward trials (n = 24), one-third of the trials were neutral trials (n = 24), and one-third of the trials were punishment trials (n = 24). No trial type will be presented more than 3 consecutive times.

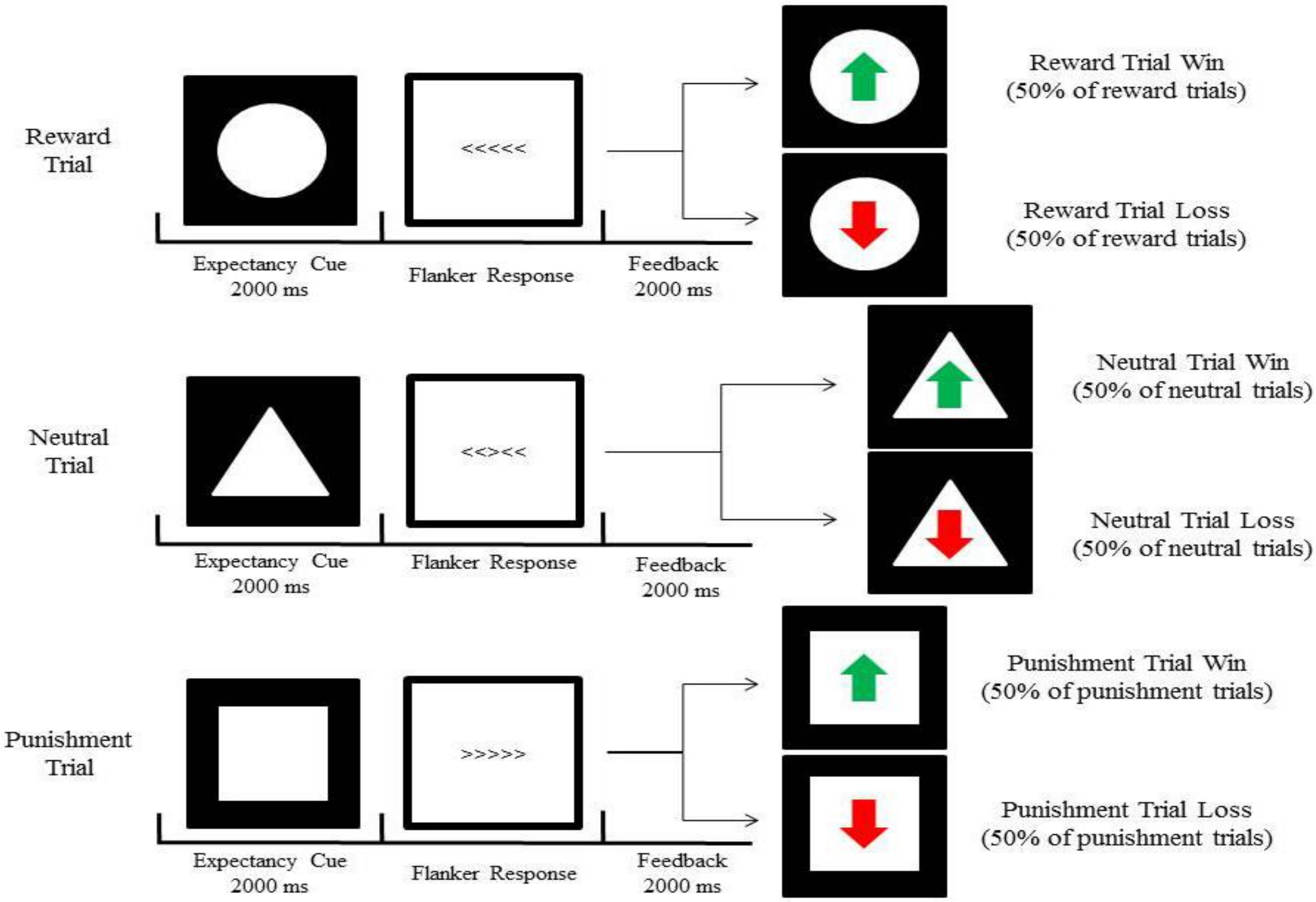

Figure 1. Experiment example trials. Between the trial cue and flankers response, there was an ISI of 500 ms. Between the flankers response and feedback, there was an ISI of 500 ms. The intertrial intervals were 4000 ms. A black screen was presented during all ISI's and ITI's.

Next, participants completed the goal-related task, which was a flankers response (Eriksen & Eriksen, 1974). Participants indicated the direction of a center arrow by pressing the left or right shift key as quickly as possible. The flankers response remained on the screen until the participant responded. On reward trials, participants were told that if they correctly responded faster than their opponent, they would win the ability to blast their opponent with noise. On neutral trials, participants were told that they could randomly win on the trials, but winning was unrelated to neither their own nor their opponent's reaction time to the flankers response. On punishment trials, participants were told that if they correctly responded faster than their opponent, they would prevent their opponent from blasting the participant with noise. However, if they did not correctly respond faster than their opponent, the participant would be blasted with noise.

Following the flankers response, participants received feedback indicating whether they did or did not beat their opponent on that trial. A white circle, triangle, or square (corresponding with the trial type) was presented with an arrow pointing either a green up arrow or red down arrow, indicating win or loss feedback, respectively.

Half of the reward trials, half of the neutral trials, and half of the punishment trials resulted in a win (n = 12 for reward trials, n = 12 for neutral trials, and n = 12 for punishment trials). The remaining trials resulted in a loss. On reward trials and punishment trials where the computer script was programmed to result with a win, participants received loss feedback if they gave an incorrect response or if their response exceed 1500 ms. All trials with incorrect responses were removed for analyses.

If a reward trial resulted in win feedback, participants were able deliver up to 10 s of a 102 dB white noise to their opponent. Upon receiving win feedback, participants indicated how long they wished for the noise blast to be (1 = *5 seconds*, 6 = 10 *seconds*). After selection of how long the noise blast would be, the "noise blast" was delivered for the length of time indicated by the participant. If a reward trial resulted in loss feedback, the game simply proceeded to the next trial. Regardless of whether a neutral trial resulted in win feedback or loss feedback, the game simply proceeded to the next trial, because neither winning nor losing resulted in any reward or punishment.

If a punishment trial resulted in win feedback, the game simply continued to the next trial. However, if a punishment trial resulted in a loss feedback, participants waited between 5 and 7 *s* as the other participant made a noise selection. A noise blast was then delivered through stereo headphones. The noise blast that was delivered at 102 dB and lasted for either 5 or 7 s.[1]

Prior to the participant arriving, the experimenter checked the noise level volume in the headphones using the Decibel 10th application on an Apple iPhone (4th generation) to ensure that 102 dB was reached by the headphones. Six practice trials occurred at the beginning of the experiment and were not included for analyses. In between each trial, participants were prompted to click the spacebar to proceed to the next trial, followed by a screen indicating that the computer is waiting on the opponent (300 *ms* – 700 *ms* waiting period). After the game, participants were carefully probed for suspicion and debriefed.

EEG Processing

Electroencephalography was recorded from 32 tin electrodes mounted in a stretch lycra Quick-Cap (Electroc-Cap, Eaton, OH) based on the 10-20 system and referenced online to the left earlobe. A ground electrode was mounted midway between FPz and Fz. A sodium-chloride based conductance gel was used to reduce impedance under 5,000 Ω. Signals were amplified with a Neuroscan SynAmps RT amplifier unit (El Paso, TX), low-pass filtered at 100 Hz, high-

[1] The volume of the noise probes do not cause damage to hearing when presented for such a brief period of time. The Occupational Safety and Health Administration recommended limit for noise exposure at 102 dB is no more than 1.5 hours a day (OSHA section 1910-95). At such levels, it takes over 1 minute of continuous exposure to create any measurable temporary threshold shift in humans, and it typically requires a temporary threshold shift in excess of 25dB before permanent threshold shift occurs (Salvendy, 1987). Because my study only used noise blasts no longer than 7s, the noise blast should not have caused any damage to hearing.

pass filtered at 60 Hz, and digitized at 500 Hz. Artifcats (e.g., horizontal eye movement and muscle) were removed by hand. Then, a regression-based eye movement correction was applied (Semlitsch, Anderer, Schuster, & Presslich, 1986), after which the data was visually inspected again to ensure proper correction.

ERP Assessment

The data was epoched from 200 ms before feedback onset until 1200 ms after feedback onset and low-pass filtered at 35 Hz. Aggregated waveforms for each feedback type were created and baseline corrected using the prestimulus activity. 12 trials were entered into the average waveform for reward trial wins, reward trial losses, neutral trial wins, neutral trial losses, punishment trial wins, and punishment trial losses. Based on past research, the RewP mean amplitude was assessed at site Cz within a window of 250-350 ms after feedback onset, where the difference between win and no-win feedback was maximal (Baker & Holroyd, 2011; Foti et al., 2011; Threadgill & Gable, 2016).

Frontal Asymmetry Assessment

Epochs 1.024 *s* in duration during the baseline periods were extracted through a Hamming window (50% taper of distal ends). Data were re-referenced using an average ears reference. Consecutive epochs were overlapped by 50% to minimize data loss due to windowing. Power values within the alpha band (8-13 Hz) were obtained using a fast Fourier transformation and averaged across epochs (Coan & Allen, 2004; Harmon-Jones & Sigelman, 2001). Asymmetry scores for lateral-frontal sites (F7/F8) were calculated by subtracting the natural log left from natural log right alpha activity. Scores were averaged together to create an index of frontal asymmetry. Because alpha activity is inversely related to cortical activation (Laufs et al., 2003; Lindsley & Wicke, 1974), higher scores indicated greater relative left frontal activity.

RESULTS

The Reward Positivity

Scores more than 3 standard deviations from the mean were removed. Means and standard deviations for the RewP are presented in Table 1.

Table 1

Means and standard deviations for RewP amplitudes

	Reward Trial	Neutral Trial	Punishment Trial
Win Feedback	19.24 (7.96)	14.18 (9.87)	19.49 (7.07)
Loss Feedback	16.16 (6.79)	14.57 (7.28)	17.96 (9.47)

Note. Standard deviations are in parentheses.

The originally proposed 3 (trial type: reward vs. neutral vs. punishment) x 2 (outcome: win vs. loss) repeated-measures analysis of variance (ANOVA) revealed a marginally significant interaction, $F(2, 84) = 2.41$, $p = .096$, $\eta_p^2 = .05$. However, some have argued that there is merit in assessing approach behavior (reward trials) on a separate dimension than withdrawal behavior (punishment trials; Carver, 2004, 2005; Watson, Wiese, Vaidya, & Tellegen, 1999). This is because reward sensitivity and threat sensitivity likely vary independently of one another (Schmidt, 1999). Therefore, because it seems prudent to assess the reward and punishment trials separately, this interaction was unpacked by examining the 2 (trial type: motivated vs. neutral) x 2 (win vs. loss) interaction within the reward and punishment trials.

A 2 (reward trial vs. neutral trial) x 2 (win vs. loss) repeated-measures ANOVA revealed a significant main effect for trial type, $F(1, 42) = 9.76$, $p = .003$, $\eta_p^2 = .19$. However, the main effect for outcome was not significant, $F(1, 42) = 2.71$, $p = .107$, $\eta_p^2 = .06$. Most importantly, there was a significant interaction, $F(1, 42) = 3.96$, $p = .053$, $\eta_p^2 = .09$ (see Figures 2 and 3).

Follow-up analyses indicated that the RewP after reward trial wins was significantly larger than the RewP after reward trial losses, $p = .012$. Additionally, reward trial wins elicited a significantly larger RewP than neutral trials wins, $p < .001$. However, there was no significant difference between either reward trial losses and neutral trial losses ($p = .282$) or neutral trial wins and neutral trial losses ($p = .843$).

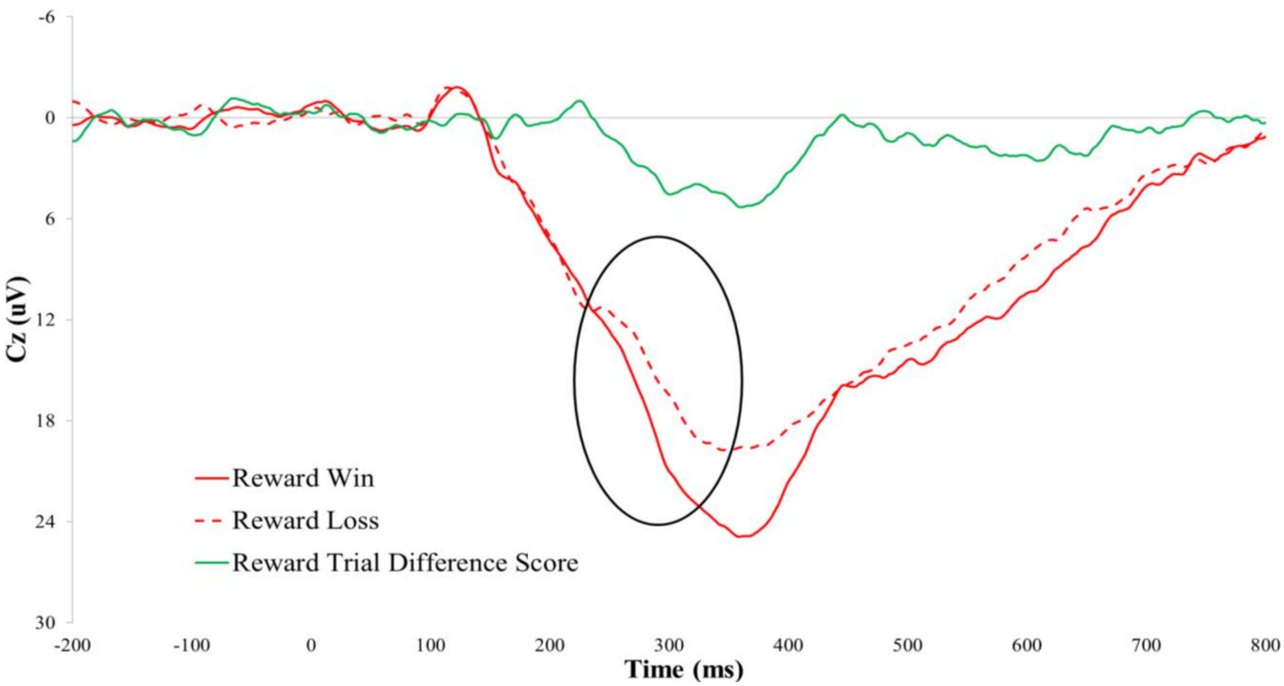

Figure 2. ERP waveforms for win and loss feedback during reward trials, as well as the difference score between reward trial win and reward trial loss (win minus loss) at site CZ. The RewP component is circled. Note that negative is plotted up by convention.

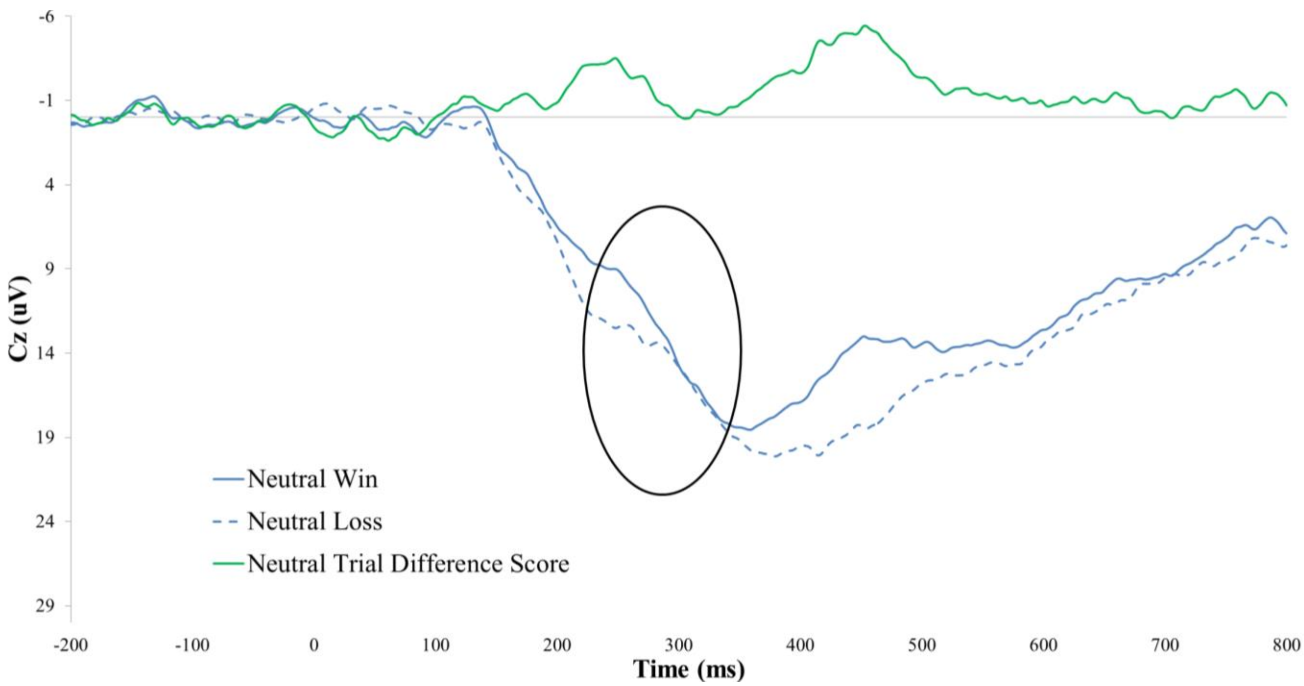

Figure 3. ERP waveforms for win and loss feedback during neutral trials, as well as the difference score between neutral trial win and neutral trial loss (win minus loss) at site CZ. The RewP component is circled.

A 2 (punishment trial vs. neutral trial) x 2 (win vs. loss) repeated-measures ANOVA revealed a significant main effect for trial type, $F(1, 42) = 19.73$, $p < .001$, $\eta_p^2 = .31$. However, there was not a main effect for outcome, $F(1, 42) = 0.19$, $p = .668$, $\eta_p^2 = .004$. Finally, there was not a significant interaction, $F(1, 42) = 0.53$, $p = .469$, $\eta_p^2 = .01$ (see Figure 4).

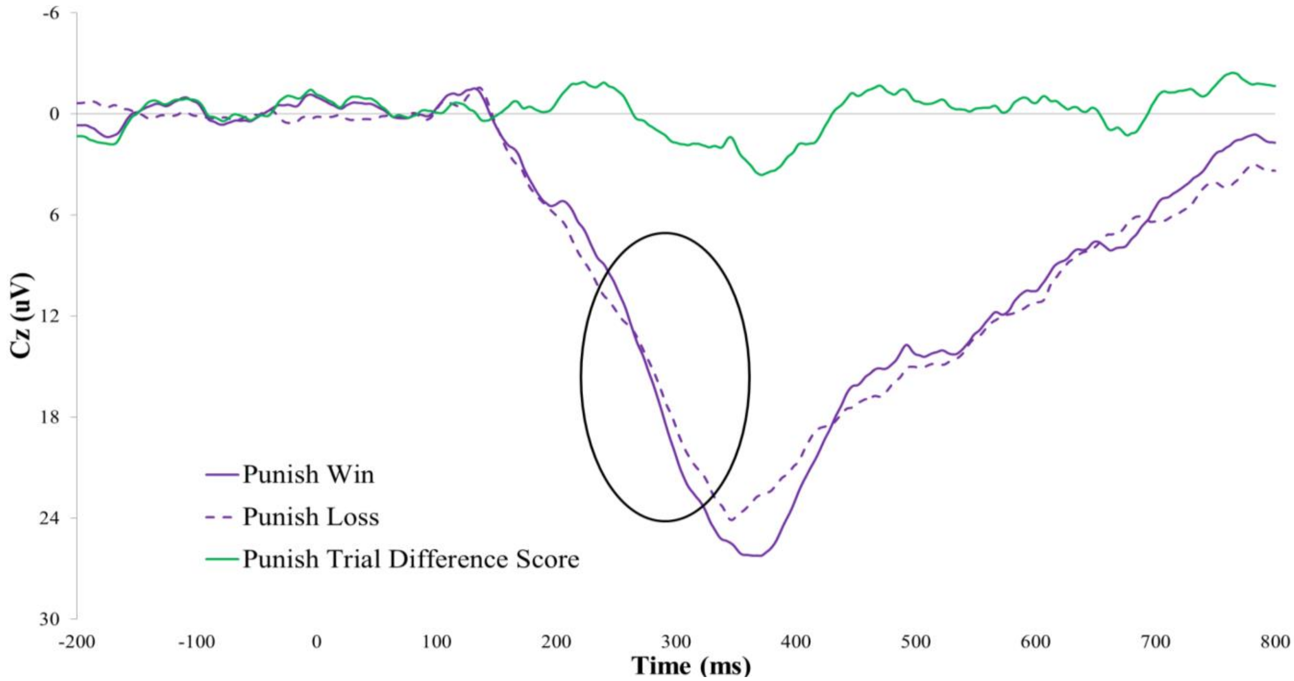

Figure 4. ERP waveforms for win and loss feedback during punishment trials, as well as the difference score between punishment trial win and punishment trial loss (win minus loss) at site CZ. The RewP component is circled.

Correlation between Aggression and RewP

Because neural correlates of approach-motivated anger have been found to be related to aggression, I conducted a correlation between the RewP to reward trial wins and aggression, as measured by length of noise blast chosen after reward trial wins. There was no relationship between the RewP difference score and aggression scores, $r(42) = -.06$, $p = .689$ (see Figure 5).[2]

[2] Because 10 participants selected the lowest possible length of noise every time they were able to blast their opponent with noise, a separate correlation was conducted with those individuals removed to make sure the lack of a relationship was not due to a floor effect. The correlation remained non-significant, $r(26) = .02$, $p = .930$.

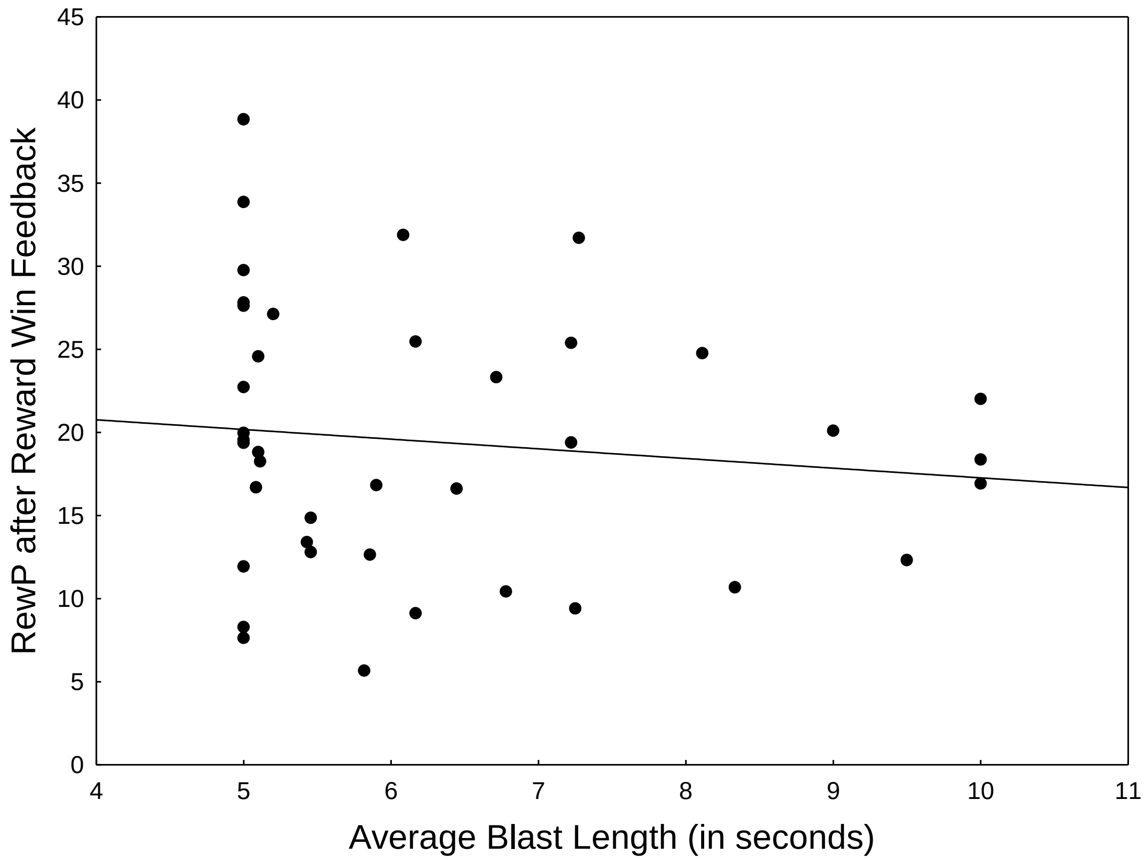

Figure 5. Relationship between RewP amplitudes after reward trial win feedback and average noise blast length.

DISCUSSION

The aim of the proposed study was to investigate whether anger, a high intensity approach-motivated negative affect, would evoke a larger RewP in a reward trial than a neutral trial in a goal-related task. Results revealed that RewP amplitudes were larger after reward trial win feedback than after reward trial loss feedback. Consistent with past work, these results suggest that the RewP is more sensitive to win feedback than loss feedback. RewP amplitudes were also larger after reward trial win feedback than neutral trial win feedback. These results suggest that approach-motivated states elicit larger RewPs than neutral states.

Together, these results suggest that anger, a high intensity approach motivated negative affect, amplifies the RewP in a goal-pursuit task when the reward is the ability to rectify the source of anger. This differs from past research examining the relationship between the RewP and anger, which found no direct relationship (Angus et al., 2015). This is likely because the current study offered a clear path by which participants were able to ameliorate their anger. In the present experiment, participants were made angry by receiving insulting feedback from a hostile opponent; after the anger induction, participants were then given the opportunity to ameliorate this anger by aggressing against the unfriendly opponent on reward trials. In contrast to past results, which found no relationship between anger and RewP amplitudes, the present research suggests that anger affects the RewP in circumstances when the goal to rectify the source of the anger-inducing situation has been attained. This is consistent with research showing that when individuals had the opportunity to mitigate the source of an anger-arousing situation, they exhibited stronger neural activity associated with approach-motivated affective states than when they were not able to engage in approach-related actions (Harmon-Jones et al., 2003). Because there is a clear path to resolve the source of conflict, the individual was able to act upon the angering situation, resulting in an enlarged RewP upon reward receipt (in this case, the ability to blast the offending opponent with a loud noise).

In an exploratory analysis, results revealed that RewP amplitudes were greater after punishment trial feedback than after neutral trial feedback. However, in contrast with the pattern of results after reward trials, as well as past research, there was no difference in RewP amplitude between win feedback and loss feedback. Because of the lack of prior research concerning how high intensity withdrawal-related states may impact the RewP, it is difficult to interpret these results at the current time. There could be a few different reasons for a lack of a difference in RewP amplitudes following win and loss feedback in punishment trials. It could be the case that participants could possibly have found no difference between wins and losses in the punishment condition, relative to outcomes of other trials in the task. Even though they may have won the trial in the punishment condition, participants may have still considered this to be akin to a loss, since they were not able to blast their opponent with a loud noise, which would have been participants' primary goal. This is consistent with research by Kujawa, Smith, Luhmann, & Hajcak (2013), who found that, in trials where participants could either win money or break even, there was a larger RewP to wins than breaking even. In contrast, in trials where participants could either lose money or break even, there was no difference in the RewP amplitudes between the two outcomes. This could possibly be interpreted as that the magnitude of the RewP between wins and losses is sensitive to reward-related outcomes in trials driven by approach-motivated states. In the present research, because punishment trial wins did not actually result in an explicit receipt of a reward, it could be the case that participants did not find the difference between wins and losses to be divergent enough.

Alternatively, it could be the case that the lack of a difference in RewP amplitude between wins and losses in punishment trials could be due to the internal conflict that occurred during the pursuit of the goal during these trials (i.e., avoiding being blasted with a loud noise by making an approach action). More specifically, there could be discord between the knowledge of the necessity of making an approach movement to avoid the noise blast and the desire to withdraw from the situation to avoid the noise blast. Recent models of the motivational dimensional model of affect have argued that both supervisory control (i.e., the opposite of conflict) and withdrawal motivation elicit different neural activity than approach-motivated affect, including both frontal alpha asymmetry (Gable, Neal, & Threadgill, in prep; Wacker, Chavanon, Leue, & Stemmler, 2008) and the feedback conflict-related N2 (Leue, Chavanon, Wacker, & Stemmler, 2009). However, because of the lack of prior research concerning the RewP in withdrawal-motivated states, more research is needed to fully understand the extent to which affective states high in withdrawal motivation impact the RewP and performance monitoring in general.

Finally, contrary to the anticipated results, there was no correlation between aggression scores and RewP amplitudes after reward trial win feedback. This may be due to differences in the measurement of aggression between past studies examining aggression in approach-motivated states and the present study. Some studies quantified aggression by measuring how unpleasant a beverage was that the participant selected to be given to the offending individual (Harmon-Jones & Sigelman, 2001; Jensen-Campbell et al., 2007). Those who selected more unpleasant beverages were considered more aggressive. Others who used the same aggression paradigm as the present research used either a continuous scale for aggression selection (Peterson et al., 2008) or used a scale with a wider range of options (Dambacher et al., 2015), which would allow a greater variance of scores. Additionally, this would have likely allowed researchers to avoid the floor effects that may have possibly impacted my study.

Recent research has found that the RewP is sensitive to approach-motivated states that occur during the pursuit of a goal (Meadows, Gable, Lohse, & Miller, 2016; Threadgill & Gable, 2016). The current study found that anger, a high intensity approach-motivated negative affect, augments the RewP upon the receipt of a reward in goal-pursuit tasks, especially when that goal brings about the resolution of an anger-inducing event. This suggests that the RewP reflects an active performance monitoring system influenced by approach-motivated goal states, regardless of affective valence. In the context of anger, this likely occurs because anger generates approach-motivated action tendencies (Brehm, 1999), which includes action-monitoring processes associated with the RewP. During this time, organisms are driven to approach a specific outcome, enhancing performance monitoring, and, therefore, the monitoring of feedback, in order to possibly aid future goal pursuit.

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APPENDIX

HUMAN SUBJECTS APPROVAL FOR STUDY

Office for Research

Institutional Review Board for the Protection of Human Subjects

THE UNIVERSITY OF ALABAMA

RESEARCH

December 17, 2015

Philip Gable, Ph.D.
Department of Psychology
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Box 870348

Re: IRB # 15-OR-126-R1 (Revision) "Approach-Motivation and Physiology"

Dear Dr. Gable:

The University of Alabama Institutional Review Board has reviewed the revision to your previously approved expedited protocol. The board has approved the change in your protocol.

Please remember that your approval period expires one year from the date of your original approval, August 20, 2015, not the date of this revision approval.

Should you need to submit any further correspondence regarding this proposal, please include the assigned IRB application number. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants.

Good luck with your research.

Sincerely,

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