Psychophysiology, 53 (2016), 733–738. Wiley Periodicals, Inc. Printed in the USA.

DOI: 10.1111/psyp.12611

Approach-motivated pregoal states enhance the reward positivity

A. HUNTER THREADGILL AND PHILIP A. GABLE
Department of Psychology, The University of Alabama, Tuscaloosa, Alabama, USA

Abstract

Past work has demonstrated that the reward positivity (RewP) indexes a performance-monitoring system sensitive to positive outcomes. However, studies have not investigated how approach-motivated states occurring in goal pursuit influence performance monitoring. Using a modified monetary incentive delay task, participants played a reaction time game evoking approach-motivated pregoal (reward trials) or neutral (no-reward trials) states. Then, they received trial feedback resulting in monetary gain or no gain. Results revealed that the RewP was larger to win feedback on reward trials than win or no-win feedback after neutral trials. P3 amplitudes were larger to infrequent feedback than frequent feedback, regardless of trial type or outcome. Furthermore, faster reaction times on reward trials related to larger RewP amplitudes after approach-motivated pregoal states. Approach-motivated pregoal states enhance RewP amplitudes for both successful and unsuccessful goal outcomes. Enhanced performance, as measured by faster reaction times, in approach-motivated pregoal states relates to enhanced performance monitoring.

Descriptors: Reward positivity, Approach motivation, Performance monitoring, Goal pursuit, Performance

Integral to goal pursuit is feedback signaling the success or failure of actions to obtain desired rewards. This action monitoring enhances processing of 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. Positive feedback evokes a larger positive deflection, as compared to negative or neutral feedback (Holroyd, Hajcak, & Larsen, 2006; Holroyd, Krigolson, & Lee, 2011; Weinberg, Riesel, & Proudfit, 2014). The RewP is potentially generated by the anterior cingulate cortex (Gehring & Willoughby, 2002; Hauser et al., 2014) and influenced by the mesocorticolimbic dopamine system, a neural network associated with reward processing (Carlson, Foti, Mujica-Parodi, Harmon-Jones, & Hajcak, 2011; Foti, Weinberg, Dien, & Hajcak, 2011).

Based on past work, the RewP may be a measure of approach-motivated positive affect (Proudfit, 2015). 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). In sum, the RewP appears to index approach motivation to rewarding feedback in goal pursuit.

Presumably, approach-motivated goal pursuit (pregoal states) should enhance performance monitoring, because such states are associated with high approach-motivated positive affect (Gable & Harmon-Jones, 2011). Functionally, pregoal states encourage pursuit and attainment of desired objects or goals (Gable, Hart, Threadgill, & Adams, 2015; Hart & Gable, 2013). Such states likely enhance sensitivity to performance of pursued rewards (Harmon-Jones, Gable, & Price, 2012; Weinberg et al., 2014). The RewP should be larger to feedback after pregoal approach-motivated states than neutral states. However, previous studies have not investigated whether individuals' motivated goal states prior to feedback impact performance monitoring. In sum, the current study sought to demonstrate that performance monitoring as measured by the RewP is enhanced by approach-motivated goal states.

We assessed neurophysiological activity in a modified monetary incentive delay (MID) task. The MID task evokes approach-motivated pregoal states or neutral states using a monetary incentive or no incentive, respectively. The task evokes dynamics of goal pursuit and attainment within the same participant within the same trial (Novak & Foti, 2015). Monetary rewards are ostensibly based on performance in a reaction time task (e.g., flanker task; Eriksen & Eriksen, 1974), and rewards or nonrewards are indicated in performance-related feedback (Gable & Harmon-Jones, 2010, 2011; Knutson, Westdorp, Kaiser, & Hommer, 2000). We predict that the RewP should be larger to reward feedback than nonreward feedback. Additionally, we predict that the RewP should be larger to feedback following approach-motivated goal states than neutral states. Accordingly, because motivated goal performance likely

Address correspondence to: Hunter Threadgill or Philip Gable, Department of Psychology, The University of Alabama, 505 Hackberry Lane, P.O. Box 870348, Tuscaloosa, AL 35487-0348, USA. E-mail: ahunterthreadgill@gmail.com or pagable@gmail.com

PSYCHOPHYSIOLOGY

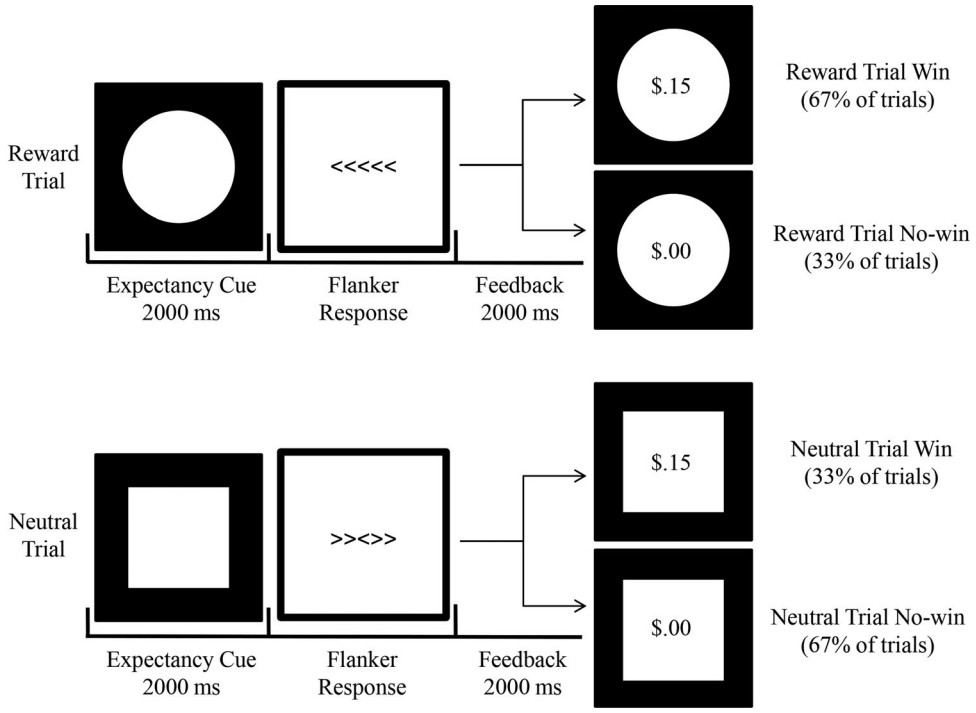

Figure 1. Experiment example trials. Between the trial cue and flanker task, there was a variable interstimulus interval (ISI) between 500–900 ms. Between the flanker response and feedback, there was a variable ISI between 300–700 ms. The intertrial interval (ITI) was 3,000–5,000 ms. A blank black screen was presented for all ISIs and ITIs.

relates to performance monitoring, reaction times to flanker tasks in approach-motivated pregoal states should predict larger RewP amplitudes. Because the RewP can potentially have strong temporal overlap with the P3 (Holroyd, Nieuwenhuis, Yeung, & Cohen, 2003; Novak & Foti, 2015), we also examined the P3 to feedback. Consistent with past work (Hajcak, Moser, Holroyd, & Simons, 2005, 2007), we predicted that infrequent feedback will elicit larger P3 amplitudes than more frequent feedback.

Method

Twenty-eight introductory psychology students participated in exchange for partial course credit. Participants were informed they could win a total of $10 by playing a reaction time game.

Each trial ($n = 120$; see Figure 1) began with a trial cue displayed in the center of a computer monitor, consisting of either a white circle or white square. Circles represented reward trial cues, indicating the opportunity to win a monetary reward based on their performance. Squares represented neutral trial cues, indicating a monetary reward could not be earned based on performance. Because trial cues gave participants the expectancy of winning money based on goal performance, reward trial cues were designed to evoke approach-motivated pregoal states relative to neutral trial cues. Half of the trials were reward trials, and half of the trials were neutral trials. No trial type was presented more than three consecutive times.

Next, participants completed the goal-related task, which was a flanker task (Eriksen & Eriksen, 1974). Participants indicated the direction of a center arrow by pressing buttons on a response pad as quickly as possible. On reward trials, participants were told that if they correctly responded faster than the average participant, they would win money on that trial. On neutral trials, participants were told they could randomly earn bonus money on that trial, but that this monetary gain was unrelated to their reaction time to the flanker task. The flanker task remained on the screen until the participant responded.

Following the flanker task, participants received feedback indicating whether they did or did not win money. A white circle or square (corresponding to the trial type) with a monetary value displayed indicated win ($0.15) or no-win ($0.00) feedback.

To enhance approach motivation on reward trials, participants were given the expectancy they could beat the average reaction time and win money by manipulating win feedback frequency. Two thirds ($n = 40$) of the reward trials resulted in win feedback (reward trial win). To give participants the impression that their efforts influenced trial outcome, as opposed to the game being fixed, the remaining one third ($n = 20$) of the trials resulted in no-win feedback (reward trial no-win). On reward trials, participants received no-win feedback for incorrect responses or if responses exceeded 1,500 ms. These trials were removed from analyses (7% removed). In contrast, on the neutral trials, two thirds of the trials resulted in no-win feedback (neutral trial no-win). The remaining one third resulted in win feedback (neutral trial win). Twelve practice trials occurred at the beginning of the experiment. After all trials, participants were paid $10 and debriefed.

EEG Assessment and Processing

Electroencephalography was recorded from 64 tin electrodes mounted in a stretch Lycra Quik-Cap (Electro-Cap, Eaton, OH) based on the 10-20 system and referenced online to the left earlobe; offline, data were rereferenced using the common average reference. 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 NeuroScan SynAmps RT amplifier unit (El Paso, TX), low-pass filtered at

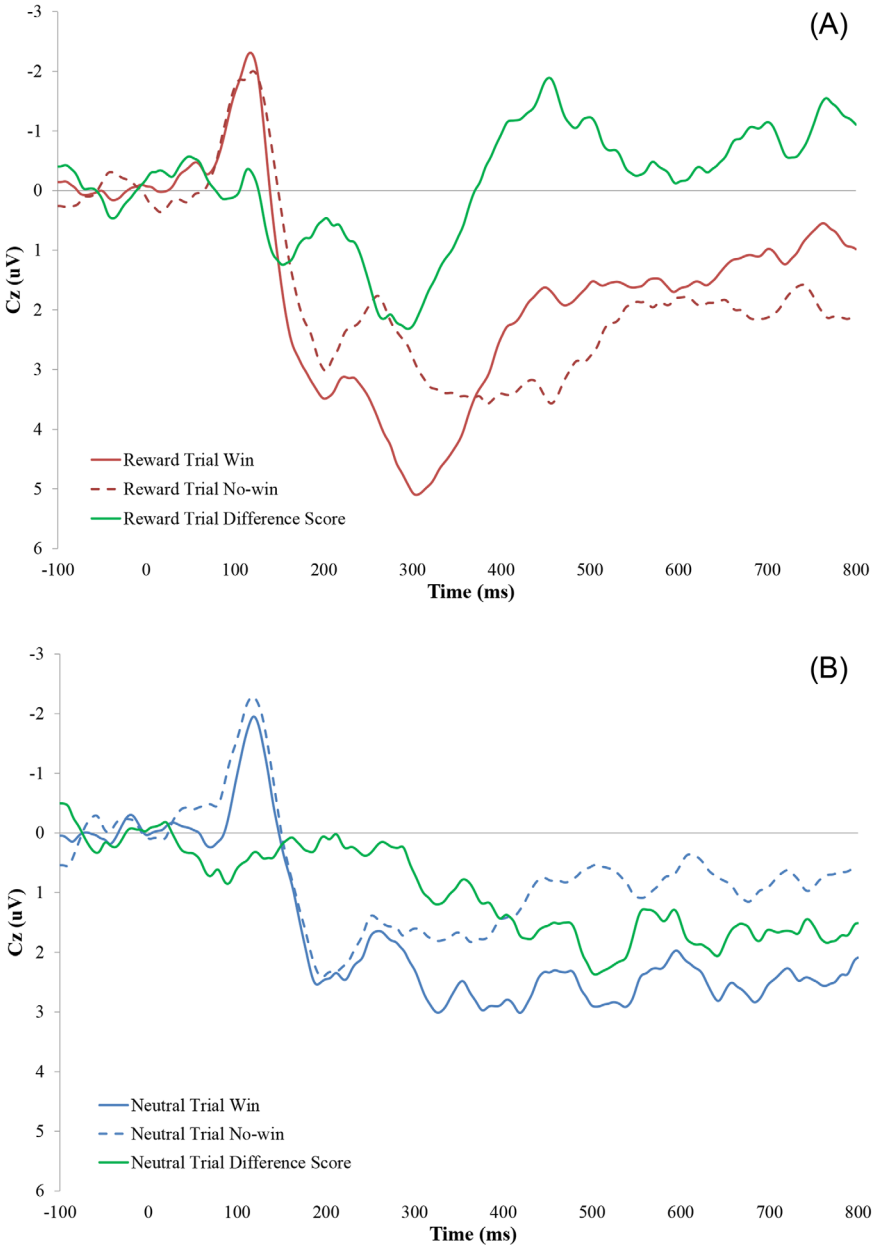

Figure 2. A: ERP waveforms for win and no-win feedback during reward trials, as well as the difference scores between reward trial win and reward trial no-win (win minus no-win) at site CZ. B: ERP waveforms for win and no-win feedback during neutral trials, as well as the difference scores between neutral trial win and neutral trial no-win (win minus no-win) at site CZ.

100 Hz, high-pass filtered at 0.05 Hz, notch filtered at 60 Hz, and digitized at 500 Hz. Artifacts (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 were visually inspected again to ensure proper correction.

The data were epoched from 100 ms before feedback onset until 1,200 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. Forty trials were entered into the average waveform for reward trial wins and neutral trial no-wins. Twenty trials were entered into the average waveform for reward trial no-wins and neutral trial wins. Reward trials with errors were excluded from ERP analyses. Based on visual inspection, 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; Weinberg et al., 2014). The P3 was assessed at site CZ within a window of 350–600 ms after feedback onset (Gajewski, Stoerig, & Falkenstein, 2008; Weinberg, Luhmann, Bress, & Hajcak, 2013).

Results

Flanker Task Reaction Times

Reaction times (RTs) were logarithmically transformed. Trials with incorrect responses or RTs more than three standard deviations

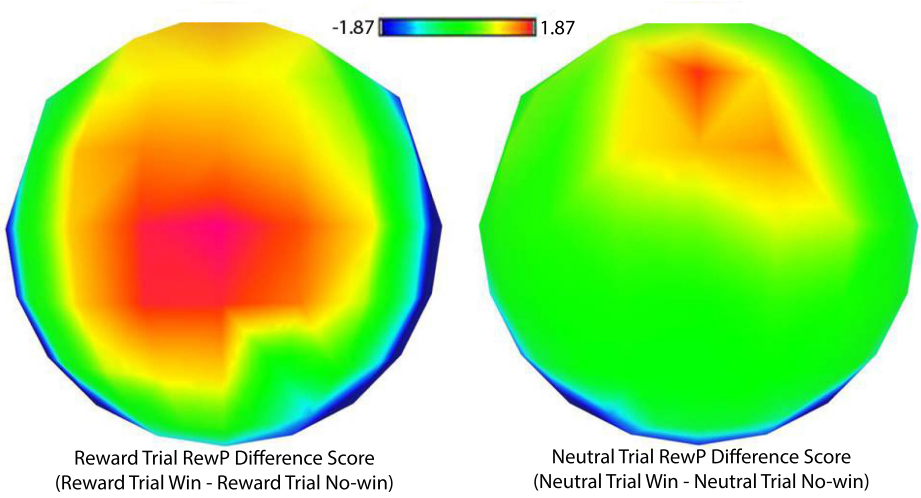

Figure 3. Scalp topography of the difference between reward trial wins and reward trial no-wins (A), and between neutral trial wins and neutral trial no-wins (B) from 250 to 350 ms.

from the mean for each stimulus were removed (7.14% of flankers after reward trial cues and 6.07% of flankers after neutral trial cues). Due to equipment malfunction, two participants' data were not included. Log-transformed means and untransformed means (M_{Raw}) are reported.

A dependent-sample *t* test comparing the reaction times to the flanker task revealed that reaction times to flankers following reward trial cues, $M = 6.21$, $SD = 0.14$ (M_{Raw} = 595.53 ms, SD = 135.23 ms), were significantly faster than reaction times to flankers following neutral trial cues, $M = 6.27$, $SD = 0.14$ (M_{Raw} = 598.30 ms, SD = 146.22 ms), $t(25) = 5.13$, $p < .001$, $d = 1.06$.

Flanker Task Accuracy Rates

For each condition, trial accuracy rates were calculated as the proportion of the number of trials answered correctly to the number of trials attempted. A dependent-sample *t* test comparing the accuracy rates to the flanker tasks revealed that accuracy rates to flankers following reward trial cues ($M = 0.93$, $SD = 0.06$) were not different than accuracy rates to flankers following neutral trial cues, $M = 0.95$, $SD = 0.05$, $t(25) = 1.72$, $p = .097$, $d = 0.34$.

The Reward Positivity

A 2 (Trial Type: reward vs. neutral) × 2 (Outcome: win vs. no-win) repeated measures analysis of variance (ANOVA) revealed that the RewP significantly varied as a function of trial type, $F(1,27) = 12.71$, $p = .001$, $\eta_p^2 = .32$, as well as a function of outcome, $F(1,27) = 18.15$, $p < .001$, $\eta_p^2 = .40$. Finally, the effect of outcome varied significantly as a function of trial type, $F(1,27) = 4.92$, $p = .035$, $\eta_p^2 = .15$ (see Figure 2).

Follow-up *t* tests indicated that the RewP after reward trial wins ($M = 4.32$, $SD = 3.57$) was significantly larger than the RewP after reward trial no-wins ($M = 2.59$, $SD = 2.15$), $t(27) = 4.15$, $p < .001$, $d = 0.99$. Additionally, reward trial wins elicited significantly larger amplitudes than neutral trial wins ($M = 2.19$, $SD = 2.38$), $t(27) = 3.34$, $p = .002$, $d = 0.66$. The RewP after neutral trial wins was marginally larger than neutral trial no-wins ($M = 1.59$, $SD = 1.84$), $t(27) = 1.83$, $p = .078$, $d = 0.36$. Finally, reward trial no-wins elicited significantly larger amplitudes than neutral trial no-wins, $t(27) = 3.01$, $p = .006$, $d = 0.58$ (see Figure 3).

The P3

A 2 (Trial Type: reward vs. neutral) × 2 (Outcome: win vs. no-win) repeated measures ANOVA revealed that the P3 did not vary as a function of trial type, $F(1,27) = 1.60$, $p = .217$, $\eta_p^2 = .06$, or as a function of outcome, $F(1,27) = 2.90$, $p = .100$, $\eta_p^2 = .10$. However, the effect of outcome varied significantly as a function of trial type, $F(1,27) = 20.26$, $p < .001$, $\eta_p^2 = .43$.

Follow-up *t* tests indicated that the P3 after reward trial no-wins ($M = 2.71$, $SD = 2.75$) was marginally larger than the P3 after reward trial wins ($M = 2.04$, $SD = 2.42$), $t(27) = 1.94$, $p = .061$, $d = 0.37$. Additionally, there was no difference between reward trial wins and neutral trial wins ($M = 2.57$, $SD = 2.45$), $t(27) = 1.03$, $p = .129$, $d = 0.19$. The P3 after neutral trial wins was significantly larger than neutral trial no-wins ($M = 1.05$, $SD = 2.07$), $t(27) = 4.37$, $p < .001$, $d = 0.84$. Finally, reward trial no-wins elicited significantly larger amplitudes than neutral trial no-wins, $t(27) = 3.43$, $p < .001$, $d = 0.67$.

Correlations Between Flanker Reaction Times and RewP

To examine how differences in flanker task responses were related to general neural activity during feedback between approach-motivated and neutral trials (Proudfit, 2015), difference scores were created between the RewP following reward trial wins and neutral trial wins, as well as between the RewP following reward trial no-wins and neutral trial no-wins. To control for individual differences in reaction times to the flanker task, a difference score was created by subtracting RTs in neutral trials from the RTs in reward trials. Lower scores indicate faster RTs on reward trials.

Faster reaction times on reward trials related to larger RewP amplitudes to reward trial win feedback, $r(24) = -.48$, $p = .012$. Furthermore, faster reaction times on reward trials related to larger RewP amplitudes to reward trial no-win feedback, $r(24) = -.69$, $p < .001$. Reaction times in approach-motivated pregoal states related to greater RewP amplitudes to reward trial win and no-win feedback (see Figure 4).

Correlations Between Flanker Task Reaction Times and P3

We examined the relationship between P3 amplitudes and RTs to flanker trials. Difference scores were created between the P3

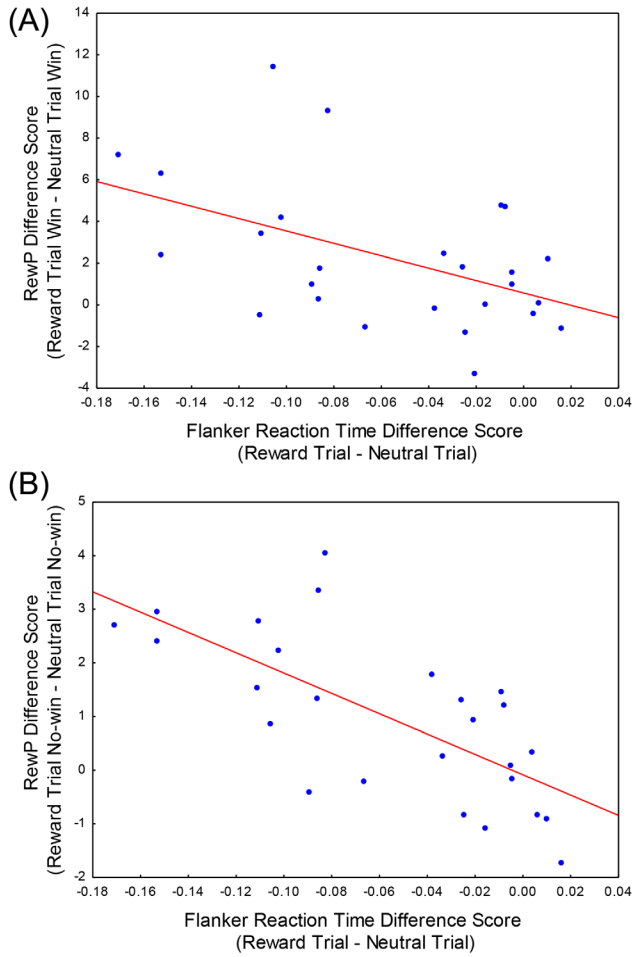

Figure 4. Relationship between RewP difference score (reward trial minus neutral trial) for wins (A) and no-wins (B) and flanker task reaction time difference scores (reward trial minus neutral trial). Larger RewP differences score indicate larger RewP amplitudes to reward trial win feedback. Smaller scores to flanker tasks indicate faster RTs on reward trials than neutral trials.

following reward trial wins and neutral trial wins, as well as between reward trial no-wins and neutral trial no-wins. These scores were correlated with the flanker task RT difference scores between reward and neutral trials. Faster reaction times on reward trials did not relate to P3 amplitudes to reward trial win feedback, $r(24) = -.20$, $p = .318$. However, faster reaction times on reward trials related to larger P3 amplitudes to reward trial no-win feedback, $r(24) = -.65$, $p < .001$.

Discussion

Results revealed that RewP amplitudes were larger after reward trial win feedback than after reward trial no-win feedback. Consistent with past work, these results suggest that the RewP is more sensitive to win feedback than no-win feedback. RewP amplitudes to reward trial wins were larger than RewP amplitudes to neutral trial wins. Also, RewP amplitudes to reward trial no-wins were larger than RewP amplitudes to neutral trial no-wins. This finding appears to be exclusive to the RewP, but not the P3. P3 amplitudes were larger to infrequent outcomes, as compared to frequent outcomes, regardless of trial type. These results suggest that approach-motivated pregoal states enhance performance monitoring as reflected by the RewP for both successful (win) and unsuccessful (no-win) outcomes.

Our results suggest that approach-motivated pregoal states elicit larger RewPs than neutral states. Individuals in pregoal states seem to be more sensitive to rewarding feedback as a result of approach motivation. We believe this enhanced reward processing is a result of greater levels of action monitoring in approach-motivated pregoal states. Approach motivation enhances performance monitoring, which in turn enhances processing of feedback indicating successful goal performance.

Faster RTs to flankers on reward trials related to larger RewP amplitudes to both reward trial win feedback and reward trial no-win feedback. These results suggest that goal-related performance in approach-motivated pregoal states relates to larger RewP amplitudes, even when goal-related effort is unsuccessful. It appears that approach motivation enhances both performance monitoring and goal-related performance. Better performance in approach-motivated pregoal states seems to relate to enhanced performance monitoring.

In the current study, feedback occurred at different frequencies to enhance approach motivation and task realism. Past research has found that infrequent feedback typically evokes larger RewPs as compared to more frequent feedback (Hajcak et al., 2007; Holroyd et al., 2011). However, in the current study RewP amplitudes to infrequent feedback (e.g., reward trial losses and neutral trial wins) were not enhanced as compared to RewP amplitudes to more frequent feedback (e.g., reward trial wins and neutral trial losses). RewP amplitudes were larger for approach-motivated pregoal trials (vs. neutral trials), as well as winning (vs. nonwinning feedback) regardless of the frequency. It appears that frequency did not drive the observed modulation of the RewP.

Consistent with much prior work, the P3 appeared to be sensitive to feedback frequency (Hajcak et al., 2005, 2007; Novak & Foti, 2015). Reward trial no-win feedback and neutral trial win feedback occurred one third of the time in the reward and neutral conditions, respectively. In contrast, reward trial wins and neutral trial no-wins occurred two thirds of the time in the reward and neutral conditions, respectively. P3 amplitudes were larger to the infrequent feedback (reward trial no-win feedback and neutral trial win feedback) than the frequent feedback (reward trial wins and neutral trial no-wins). The P3 varied as a function of frequency, but the RewP did not. This suggests that the two components are measuring two different processes, despite the temporal proximity of the two ERP components (Hajcak et al., 2007). Interestingly, larger P3 amplitudes for infrequent feedback (unexpected loss) on reward trials were related to faster reaction times. Greater effort in approach-motivated pregoal states may relate to enhanced processing of unexpected feedback. In conclusion, the P3 and RewP are both sensitive to performance outcomes: the P3 is sensitive to the infrequency of performance outcome, while the RewP is sensitive to motivated goal states.

In sum, the RewP appears to reflect an active performance monitoring system influenced by approach-motivated pregoal states. Approach-motivated pregoal states stem from the mesocorticolimbic dopamine system and drive an organism to attain a desired outcome (Depue & Collins, 1999). The dopaminergic system also enhances performance monitoring (Carlson et al., 2011). Future studies should examine how enhanced performance monitoring during approach-motivated goal pursuit may aid future goal pursuit by modifying behavior and increasing the likelihood of attaining future rewards.

References

Angus, D. J., Kemkes, K., Schutter, D. J. L. G., & Harmon-Jones, E. (2015). Anger is associated with reward-related electrocortical activity: Evidence from the reward positivity. *Psychophysiology*. Advance online publication. doi: 10.1111/psyp.12460

Baker, T., & Holroyd, C. (2011). Dissociated roles of the anterior cingulate cortex in reward and conflict processing as revealed by the feedback error-related negativity and N200. *Biological Psychology*, *87*, 25–34. doi: 10.1016/j.biopsycho.2011.01.010

Bress, J. N., & Hajcak, G. (2013). Self-report and behavioral measures of reward sensitivity predict the feedback negativity. *Psychophysiology*, *50*, 610–616. doi: 10.1111/psyp.12053

Carlson, J. M., Foti, D., Mujica-Parodi, L. R., Harmon-Jones, E., & Hajcak, G. (2011). Ventral striatal and medial prefrontal BOLD activation is correlated with reward-related electrocortical activity: A combined ERP and fMRI study. *NeuroImage*, *57*, 1608–1616. doi: 10.1016/j.neuroimage.2011.05.037

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, *67*, 319–333. doi: 10.1037/0022-3514.67.2.319

Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences*, *22*, 491–569. doi: 10.1017/S0140525X99352043

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*, 143–149. doi: 10.3758/BF03203267

Foti, D., Weinberg, A., Dien, J., & Hajcak, G. (2011). Event-related potential activity in the basal ganglia differentiates rewards from nonrewards: Temporospatial principal components analysis and source localization of the feedback negativity. *Human Brain Mapping*, *32*, 2267–2269. doi: 10.1002/hbm.21357

Gable, P. A., & Harmon-Jones, E. (2010). The effect of low versus high approach-motivated positive affect on memory for peripherally versus centrally presented information. *Emotion*, *10*, 599–603. doi: 10.1037/a0018426

Gable, P. A., & Harmon-Jones, E. (2011). Attentional consequences of pregoal and postgoal positive affects. *Emotion*, *11*, 1358–1367. doi: 10.1037/a0025611

Gable, P. A., Hart, W., Threadgill, A. H., & Adams, D. (2015). *High approach-motivated positive affect enhances goal performance*. Manuscript submitted for publication.

Gajewski, P. D., Stoerig, P., & Falkenstein, M. (2008). ERP—Correlates of response selection in a response conflict paradigm. *Brain Research*, *1189*, 127–134. doi: 10.1016/j.brainres.2007.10.076

Gehring, W. J., & Willoughby, A. R. (2002). The medial frontal cortex and the rapid processing of monetary gains and losses. *Science*, *295*, 2279–2282. doi: 10.1126/science.1066893

Hajcak, G., Moser, J. S., Holroyd, C. B., & Simons, R. F. (2005). Brain potentials associated with expected and unexpected good and bad outcomes. *Psychophysiology*, *42*, 161–170. doi: 10.1111/j.1469-8986.2005.00278.x

Hajcak, G., Moser, J. S., Holroyd, C. B., & Simons, R. F. (2007). It's worse than you thought: The feedback negativity and violations of reward prediction in gambling tasks. *Psychophysiology*, *44*, 905–912. doi: 10.1111/j.1469-8986.2007.00567.x

Harmon-Jones, E., Gable, P. A., & Price, T. F. (2012). The influence of affective states varying in motivational intensity on cognitive scope. *Frontiers in Integrative Neuroscience*, *6*, 73. doi: 10.3389/fnint.2012.00073

Hart, W, & Gable, P. A. (2013). Motivating goal pursuit: The role of affect motivational intensity and activated goals. *Journal of Experimental Social Psychology*, *49*, 922–926. doi: 10.1016/j.jesp.2013.05.002

Hauser, T. U., Iannaccone, R., Stämpfli, P., Drechsler, R., Brandeis, D., Walitza, S., & Brem, S. (2014). The feedback-related negativity (FRN) revisited: New insights into the localization, meaning and network organization. *NeuroImage*, *84*, 159–168. doi: 10.1016/j.neuroimage.2013.08.028

Holroyd, C. B., Hajcak, G., & Larsen, J. T. (2006). The good, the bad and the neutral: Electrophysiological responses to feedback stimuli. *Brain Research*, *1105*, 93–101. doi: 10.1016/j.brainres.2005.12.015

Holroyd, C. B., Krigolson, O. E., & Lee, S. (2011). Reward positivity elicited by predictive cues. *NeuroReport*, *22*, 249–252. doi: 10.1097/WNR.0b013e328345441d

Holroyd, C. B., Nieuwenhuis, S., Yeung, N., & Cohen, J. D. (2003). Errors in reward prediction are reflected in the event-related brain potential. *NeuroReport*, *14*, 2481–2484. doi: 10.1097/01.wnr.0000099601.41403.a5

Knutson, B., Westdorp, A., Kaiser, E., & Hommer, D. (2000). fMRI visualization of brain activity during a monetary incentive delay task. *NeuroImage*, *12*, 20–27. doi: 10.1006/nimg.2000.0593

Lange, S., Leue, A., & Beauducel, A. (2012). Behavioral approach and reward processing: Results on feedback-related negativity and P3 component. *Biological Psychology*, *89*, 416–425. doi: 10.1016/j.biopsycho.2011.12.004

Novak, K. D., & Foti, D. (2015). Teasing apart the anticipatory and consummatory processing of monetary incentives: An event-related potential study of reward dynamics. *Psychophysiology*, *52*, 1470–1482. doi: 10.1111/psyp.12504

Proudfit, G. H. (2015). The reward positivity: From basic research on reward to a biomarker for depression. *Psychophysiology*, *52*, 449–459. doi: 10.1111/psyp.12370

Semlitsch, H. V., Anderer, P., Schuster, P., & Presslich, O. (1986). A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. *Psychophysiology*, *23*, 695–703. doi: 10.1111/j.1469-8986.1986.tb00696.x

Sutton, R. S., & Barto, A. G. (1998). *Reinforcement learning: An introduction*. Cambridge, MA: MIT Press.

Weinberg, A., Luhmann, C. C., Bress, J. N., & Hajcak, G. (2013). Better late than never? The effect of feedback delay on ERP indices of reward processing. *Cognitive, Affective, and Behavioral Neuroscience*, *12*, 671–677. doi: 10.3758/s13415-012-0104-z

Weinberg, A., Riesel, A., & Proudfit, G. H. (2014). Show me the money: The impact of actual rewards and losses on the feedback negativity. *Brain and Cognition*, *87*, 134–139. doi: 10.1016/j.bandc.2014.03.015

Yeung, N., Holroyd, C. B., & Cohen, J. D. (2005). ERP correlates of feedback and reward processing in the presence and absence of response choice. *Cerebral Cortex*, *15*, 535–544. doi: 10.1093/cercor/bhh153

(Received July 21, 2015; Accepted December 18, 2015)