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Did I do that? The association between action video gaming experience and feedback processing in a gambling task

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ABSTRACT

The association between action video game experience and the neural correlates of feedback processing related to positive and negative outcomes was examined in a virtual Blackjack game in combination with event-related brain potentials (ERPs). The behavioral data revealed that the frequency of various outcomes was not related to action gaming experience, indicating that the associations between action gaming experience and the ERP correlates of feedback processing are unlikely to result from variation in motivation or skill related to the Blackjack game between the gamers and non-gamers. The ERP data revealed that action gaming experience was not related to the processing of positive feedback related to wins, or negative feedback for losses that resulted from the joint action of the player and dealer. In contrast, action gaming experience was associated with a reduction in the amplitude of the ERPs elicited by negative feedback wherein the loss resulted from the direct action of the individual (i.e., busts). Together these data may indicate that action gaming is associated with a reduced sensitivity to feedback related to negative outcomes resulting from the direct action of the individual.

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1. Introduction

Playing video games represents a ubiquitous form of entertainment beginning in childhood and continuing into adulthood. Action video games, wherein the player navigates a virtual world with the objective of killing enemies or destroying the resources of combatants, represent one of the most popular genres in the market (Entertainment Software Association, 2014). The influence of this genre of games on cognition, emotion, and social interaction has been the focus of intense investigation (see Anderson et al., 2010; Powers, Brooks, Aldrich, Palladino, & Alfieri, 2013). In an extensive meta-analysis of the perception and cognition literatures, Powers et al. demonstrated that action gaming has widespread effects on cognition as related to executive function, motor skill, spatial imagery, and visual processing. Additionally, there is some evidence that action gaming may be associated with an increase in risky decision-making. Bailey, West, and Kuffel (2013) reported that action gaming experience was associated with poor performance in the risk task that resulted from an increase in the number of risky choices made in the task, and this was accompanied by decreased sensitivity to feedback in the probabilistic selection task. In the current study, we sought to extend these findings by exploring the neural basis of the association between individual differences in action gaming experience and feedback processing in the context of risky decision-making by examining event-related brain potentials (ERPs) elicited during the performance of a virtual Blackjack game (West, Bailey, Tiernan, Boonsuk, & Gilbert, 2012).

1.1. Racing games and risky decision-making

While the relationship between action gaming and risky decision-making has not been widely considered, there is ample evidence demonstrating that experience with racing video games can affect risky decision-making. Racing video games appear to be particularly attractive to individuals predisposed to an increased risk of automobile accidents and deaths (National Highway Traffic Safety Administration, 2009), and the time spent playing racing games is associated with an increase in risky driving behavior and a decrease in cautious driving behavior in both adolescents and adults (Fischer, Kubitzki, Guter, & Frey, 2007). Complementing these individual difference data, laboratory studies demonstrate

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that playing a racing game can result in an increase in positive attitudes towards risk-taking and greater risk-taking behavior in a simulated driving task (Fischer et al., 2007, 2009). Furthermore, the effect of driving games on risk-taking appears to extend beyond the context of driving as recent evidence revealed that playing a racing game for 25 min decreased individuals interest in participating in a preventative health screening (Kastenmüller, Fischer, & Fischer, 2014). Together the limited evidence related to risky decision-making and action gaming, and the more extensive literature related to experience with racing games, indicates that gaining a clearer understanding of how experience with these media influences feedback processing related to risky decision-making could represent a valuable contribution to the literature.

1.2. ERPs and feedback processing

ERPs have been used extensively to study the neural correlates of feedback processing related to gains and losses in a variety of gambling and reinforcement learning paradigms (see Walsh & Anderson, 2012). The most commonly studied components represent transient neural activity over the medial frontal region that may originate from the anterior cingulate cortex (ACC; Gehring & Willoughby, 2002; Foti, Weinberg, Dien, & Hajcak, 2011). The feedback negativity (FN; Hajcak, Moser, Holroyd, & Simons, 2007) or feedback-related negativity (FRN; Walsh & Anderson, 2012; Gehring & Willoughby, 2002; Holroyd & Coles, 2002) represents a transient negativity over the frontal-central midline region that is greater in amplitude for losses than for gains around 300 ms after feedback is presented. The P2 or P2a (Holroyd, Pakzad-Vaezi, & Krigolson, 2008; Potts, Martin, Burton, & Montague, 2006) precedes the FN and reflects greater positivity for gains, particularly when unexpected, than for losses over the frontal-central midline region that peaks around 200 ms after feedback is presented. In the virtual Blackjack game used in the present study, the P2-FN-P3a component distinguishes two types of losses (i.e., losses and busts) from wins and ties (West et al., 2012, West, Bailey, Anderson, & Kieffaber, 2014). Losses result when the player's total is less than the total of the virtual dealer, and can be considered to arise from the joint action of the player and dealer. In contrast, busts result when the player's total exceeds 21, and can be considered to arise from the action of the player.

In addition to the P2-FN-P3a, there are sustained ERP components over the frontal, parietal, and occipital regions that are sensitive to feedback processing in the Blackjack game that have not been characterized in more simple gambling tasks. West, Bailey, Anderson, & Kieffaber (2014, 2012) have observed slow wave activity over the lateral frontal and parietal regions that distinguishes losses from wins and ties following the P2-FN-P3a. The lateral frontal slow wave activity may reflect recruitment within the inferior frontal gyrus or anterior temporal cortex, while the parietal slow wave activity appears to reflect activity within the posterior cingulate (West, Bailey, Anderson, & Kieffaber, 2014, West, Tiernan, Kieffaber, Bailey, & Anderson, 2014). These findings indicate that feedback processing represents a temporally extended process that can persist for 1500–2000 ms after feedback is delivered (West et al., 2012, West, Bailey, Anderson, & Kieffaber, 2014). This pattern of transient medial frontal and sustained lateral frontal and posterior neural activity associated with feedback processing is similar to conflict and error-related activity that has been associated with dynamic adjustments of cognitive control across trials in the color-word and counting Stroop tasks (Bailey, West, & Anderson, 2010; West & Travers, 2008). Drawing analogy from the cognitive control literature, West, Bailey, Anderson, & Kieffaber (2014, 2012) have suggested that this slow wave activity may reflect sustained processing associated with dynamic adjustments of information processing, which guides decision-making over time in the Blackjack game.

1.3. The current study

In the current study, we examined the relationship between action gaming experience and the ERP correlates of feedback processing related to four outcomes (i.e., ties, wins, losses, busts) in a virtual Blackjack game (West et al., 2012). This task was designed to simulate an engaging online gaming environment and allows one to measure ERPs associated with feedback processing related to gains (i.e., wins versus ties) and losses resulting from either the action of the player (i.e., busts) or the joint action of the player and a virtual dealer (i.e., losses). The inclusion of ties provides an opportunity to distinguish between the neural correlates of gains and losses that may be difficult to disentangle in gambling tasks wherein only binary outcomes (i.e., gains or losses) are represented (e.g., Gehring & Willoughby, 2002). Given evidence that action gaming experience may be associated with a reduction in reinforcement learning driven by positive and negative feedback (Bailey et al., 2013), we expected that there would be a reduction in the amplitude of transient medial frontal activity (i.e., P2-FN-P3a) and slow wave activity over the lateral frontal and posterior regions related to feedback processing that distinguishes wins, losses, and busts from ties. Based upon research examining the relationship between action gaming experience and affective information processing revealing both linear and non-linear associations between gaming experience and ERP amplitude (Bailey, West, & Anderson, 2011), we divided the action gamers into those with low, moderate, or high levels of experience. Partial Least Squares (PLS) Analysis (Lobaugh, West, & McIntosh, 2001) was used to analyze the ERP data. This method is well suited for identifying variation in the amplitude of ERP components related to the experimental design (i.e., that differ for wins, ties, losses and busts) and individual differences in action gaming experience across the full spatial-temporal distribution of the ERPs in a single analysis (McIntosh & Lobaugh, 2004).

2. Method

2.1. Participants

Ninety-eight male university students were recruited to participate in this study based on their responses to a media usage questionnaire, which they completed twice; once at least 2 weeks prior to participation in the laboratory session as part of a larger screening exercise, and once during the laboratory session. Individuals who reported spending two or fewer hours per week playing video games in the screening were recruited as low gamers. Individuals who reported spending ten or more hours per week playing video games and reported that they often or always played first-person shooter (i.e., action) video games in the screening were recruited as gamers. Data from twelve participants were excluded from the analyses due to misunderstanding how to play the Blackjack game (1), excessive artifact in the EEG data (1), a large (i.e., ≥5 h) increase or decrease in the number of hours reported playing video games per week between the initial screening and the laboratory session (5), or having fewer than five trials contribute to the ERP averages for one of the four outcomes (3), leaving 86 participants in the sample.

The dataset for the analyses included 70 individuals. In the 44 gamers, the median number of hours played per week was 20. Nineteen individuals played less than 20 h per week and were classified as moderate gamers ($M = 10$ h per week, $SD = 5$), and 25 individuals played 20 or more hours per week and were classified

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