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The interaction between state and dispositional emotions in decision making: An ERP study

Yingying Wang [a], Ruolei Gu [b], Yue-jia Luo [c], Chenglin Zhou [a,*]

[a] Department of Sport Psychology, School of Sport Science, Shanghai University of Sport, Shanghai 200438, China
[b] CAS Key Laboratory of Behavioral Science, Institute of Psychology, Beijing 100101, China
[c] Institute of Affective and Social Neuroscience, Shenzhen University, Shenzhen 5108060, China

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ABSTRACT

In this study, to investigate the influence of incidental emotions on decision making in high-anxious individuals, participants were required to perform a monetary gambling task. Behavioral and electroencephalography responses were recorded to explore the stages of option assessment and outcome evaluation during decision making, respectively. Incidental emotions were elicited by facial expression pictures presented on the background, which included four conditions (control, neutral, fearful, and happy). Results showed smaller feedback-related negativity (FRN) amplitudes in high-anxious participants than low-anxious participants in the control, neutral, and fearful conditions, but not in the happy condition, for small outcomes. The P3 amplitudes were larger in high-anxious participants compared to their counterparts in the fearful and happy conditions, but not in the other conditions. In short, the interaction effects between trait anxiety and facial emotions manifested on the outcome evaluation stage of decision making.

1. Introduction

Human emotions play a powerful role in the decision making process. The influence of emotion on decision making is common in everyday life and has drawn much attention from researchers (Kassam, 2015; Lerner, Li, Valdesolo, & Kassam, 2015; Phelps, Lempert, & Sokol-Hessner, 2014). State emotions are transient responses associated with the current situation, while dispositional emotions represent a tendency to react with a specific emotion relatively independent of the situation that elicited that emotion (Bekker, Legare, Stacey, O'Connor, & Lemyre, 2003; Lerner & Keltner, 2000). According to previous literature, both state emotions and dispositional emotions have significant impacts on decision making (Luo & Yu, 2015; Pittig, Pawlikowski, Craske, & Alpers, 2014; Proudfit, 2015). First, the emotional states of an individual may affect decision-making by modulating the cognitive evaluation of different options and outcomes (Quartz, 2009). For example, participants under the influence of negative emotions are less likely to take economic risks (Yuen & Lee, 2003). Second, dispositional emotions reflect an individual's predisposition to respond to the environment and therefore have implications in his/her behavioral patterns. For example, high level of trait impulsivity is associated with a tendency to be exposed to risk-related behaviors such as drug use and pathological gambling (Martin & Potts, 2009). However, little is known about their interaction effects on decision making, which is the main interest of the current study. In light of our previous research (Gu, Ge, Jiang, & Luo, 2010; Gu, Huang, & Luo, 2010; Luo et al., 2014; Xu et al., 2013), we focused on trait anxiety and explored how state emotions influence decision making in anxious people.

Decision making can be divided into three stages, including option assessment, action execution, and outcome evaluation (Paulus, 2005). First, an individual collects the information associated with different options and make comparisons to determine an optimal strategy; following option assessment, the individual completes an action according to the preferences established in the first stage; finally, the individual receives the outcome feedback of his/her action and evaluate its values (Ernst & Paulus, 2005; Platt, 2002). If the outcome falls short of his/her prior expectations, the individual would update the expected value of the chosen option and might make a different decision in similar occasions. Trait anxiety, which refers to a broad predisposition to experience anxiety symptoms, influences both option assessment and outcome evaluation during decision making (Gu, Ge, Jiang, & Luo, 2010; Maner et al., 2007; Paulus, 2005). Regarding option assessment, because the uncertainty in the action-outcome relationship may evoke

* Corresponding author.
E-mail address: chenglin.600@126.com (C. Zhou).

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threat-related processing biases and negative feelings, individuals with high level of anxiety tend to be more risk aversive and prefer certain alternatives (Eisenberg, Baron, & Seligman, 1998; Peng, Xiao, Yang, Wu, & Miao, 2014). Regarding outcome evaluation, researchers often use two event-related potential (ERP) components to measure this psychological process. The first one is called feedback-related negativity (FRN), which is a negative deflection that peaks approximately 250 ms after feedback onset with a topographic maximum in the fronto-central region (San Martín, 2012). This component is more pronounced for negative feedback than for positive feedback (Foti, Weinberg, Dien, & Hajcak, 2011; Gehring & Willoughby, 2002). Another one is the P3 component. The P3 in decision making literature is a centro-parietal positivity that reaches its peak following the FRN (Molnár, 1999; Polich, 2007). The amplitude of this component increases as a funcition of the emotional significance of an outcome (Polezzi, Sartori, Rumiati, Vidotto, & Daum, 2010; San Martín, 2012). Previous research has found the modulation effect of trait anxiety levels on outcome evaluation. Specifically, these studies have revealed decreased amplitude of the FRN for monetary losses than gains in high-anxious individuals compared to their low-anxious counterparts (Gu, Ge, Jiang, & Luo, 2010; Gu, Huang, & Luo, 2010; Takács et al., 2015). The cognitive process underlying the FRN is still debated. Researchers disagree on whether the FRN reflects a reward prediction error that is selectively elicited by negative outcomes (Holroyd & Coles, 2002; Nieuwenhuis, Holroyd, Mol, & Coles, 2004) or a general signal of expectation violation (Cavanagh, Figueroa, Cohen, & Frank, 2012; Sambrook & Goslin, 2014). However, it is widely accepted that the FRN amplitude is sensitive to the expectedness of the outcome, such that unexpected outcome induces a larger FRN than expected ones (Hajcak, Moser, Holroyd, & Simons, 2007; Holroyd & Coles, 2002). To explain the FRN findings associated with anxiety, it is worth noting that high-anxious individuals are more likely to expect negative outcomes in the future (Mitte, 2007; Shepperd, Grace, Cole, & Klein, 2005; Wray & Stone, 2005). Consequently, their FRN response to monetary losses decreases (Gu, Ge, Jiang, & Luo, 2010). Taken together, both behavioral pattern and neural activity during decision making could be modulated by individual levels of trait anxiety.

On the other hand, state emotions elicited by experimental materials (e.g., emotional faces) could also influence decision making, even though they are irrelevant (Luo & Yu, 2015). This kind of affective states are called "incidental emotions," as opposed to "integral emotions" elicited by the decision at hand (Keltner & Lerner, 2010; Lerner & Keltner, 2000; Lerner, Li, Valdesolo, & Kassam, 2015). In general, positive incidental emotions are more likely to induce optimistic judgments, whereas negative incidental emotions induce pessimistic judgments (Lerner et al., 2015). For instance, sad movie clips led to more risk-avoidant decisions compared to neutral and positive clips (Yuen & Lee, 2003). One of our recent studies revealed that incidental emotions also modulate outcome evaluation, such that both the FRN and the P3 are sensitive to the valence of incidental emotions (Zhao, Gu, Tang, Yang, & Luo, 2016).

Interestingly, trait anxiety may interact with incidental emotions. This idea is inspired by the fact that high-anxious people have different behavioral and neural responses to emotional facial expressions. For example, in a simple task that asked participants to judge the color of faces, the reaction time to unconsciously presented fearful faces was negatively correlated with individual level of trait anxiety (Etkin et al., 2004). For another example, fearful expressions associated with negative experience induced stronger activation of amygdala (Morris et al., 1998; Whalen et al., 1998), and high-anxious individuals showed increased amygdala responses to both attended and unattended threat-related stimuli (Bishop, Duncan, & Lawrence, 2004). In contrast, Somerville, Kim, Johnstone, Alexander and Whalen (2004) found that high-anxious people showed decreased activation of amygdala when being exposed to happy expressions. Although the aforementioned findings were not derived from decision making research, they all point to a possibility that the impact of incidental emotions on decision making may show diversity among high- and low-anxious persons. Particularly, trait anxiety is strongly related to an attentional bias on negative information, even though the information is task-irrelevant (Bishop, 2009; Fox, Russo, & Georgiou, 2005; MacLeod & Mathews, 1988; Mogg & Bradley, 1999). Compared to their low-anxious counterparts, the cognitive task performance of high-anxious participants are more likely to be interfered by incidental but emotionally aversive stimuli, because they showed a tendency to allocate more attentional resources to this kind of stimuli (Bishop, 2007). According to Miu, Heilman, & Houser (2008), distractions by incidental emotions unrelated to the task may lead to impaired decision-making in high-anxious participants (see also Engelmann, Meyer, Fehr, & Ruff, 2015). We therefore predicted that the influence of negative incidental emotions on decision making would be enlarged among high-anxious individuals compared to low-anxious individuals.

Using a risk gambling task accompanied with the presentation of emotional faces (neutral, fearful, and happy), the current study compared the impact of incidental emotions on decision making between high- and low-anxious participants. Responses to emotion faces were reflected by the N170 component, which reflects early face encoding and is modulated by the valence of emotional expressions (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Campanella, Quinet, Bruyer, Crommelinck, & Guerit, 2006; George, Evans, Fiori, Davidoff, & Renault, 1996; Krombholz, Schaefer, & Boucsein, 2007). In each trial of the gambling task, after the presentation of facial expressions, participants make a forced-choice between a low-risk option and a high-risk option, and receive corresponding outcome feedback in each trial (Gehring & Willoughby, 2002). Seeing that the expected values of two options were set as equal, a tendency of choosing the low-risk option is defined as risk-avoidance, and the opposite is defined as risky behavior. On the behavioral level, the behavioral tendency of choosing between risky and risk-avoidant options was recorded. We predicted that the feelings of fear would elicit a stronger tendency of risk-avoidance. That is, participants would be more likely to choose the low-risk option in the fearful condition. Furthermore, this effect would be more prominent in high-anxious participants than their low-anxious counterparts. On the ERP level, the FRN and the P3 component were selected. We predicted that for high-anxious participants, the influence of fearful faces on the FRN and P3 amplitudes would be stronger. Specifically, the between-group effect on the ERP components (manifested as a smaller FRN and a larger P3 among high-anxious participants, respectively) would be most prominent in the fearful condition. On the contrary, the influence of happy faces on behavioral and ERP measure might be weaker in high-anxious participants compared to low-anxious participants.

2. Methods

2.1. Participants

One hundred and twenty-one undergraduate students from Shenzhen University participated in the experiment and were screened with the Chinese version of the Trait form of Spielberger's State-Trait Anxiety Inventory (STAI-T). The scale has demonstrated good internal consistency as well as convergent and discriminant validity (Shek, 1993; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The scores of STAI-T (43.56 ± 6.74) in our sample did not significantly differ from the normative data provided by Li and