Biological Psychology 124 (2017) 30–38

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Neural correlates of the impact of prior outcomes on subsequent monetary decision-making in frequent poker players

D. Brevers [a,b,*], Q. He [c], G. Xue [d], A. Bechara [a]

[a] Department of Psychology, and Brain and Creativity Institute, University of Southern California, Los Angeles, CA, USA
[b] Laboratory of Medical Psychology and Addictology, Faculty of Medicine, Brugmann-campus, Université Libre de Bruxelles, Brussels, Belgium
[c] Faculty of Psychology, Southwest University, Chongqing, China
[d] Center for Brain and Cognitive Learning Sciences, Beijing Normal University, Beijing, China

ARTICLE INFO

Article history:
Received 7 September 2016
Received in revised form 8 January 2017
Accepted 22 January 2017
Available online 23 January 2017

Keywords:
Decision-making
fMRI
Poker players
Loss-chasing
Dorsal premotor cortex

ABSTRACT

Individuals have a tendency to be more risky in their choices after having experienced a monetary loss, than after a reward. Here, we examined whether prior outcomes influence differently the patterns of neural activity of individuals who are used to taking monetary risk, namely poker players. High-frequency poker players and non-gamblers were scanned while performing a controlled task that allowed measuring the effect of prior outcomes on subsequent decisions. Both non-gamblers and poker players took more risks after losing a gamble than after winning one. Neuroimaging data revealed that non-gamblers exhibited higher brain activation than poker players when pondering a decision after losing, as compared to after winning. The opposite was found in poker players. This differential pattern of activation was observed in brain regions involved in high-order motor processes (the dorsal premotor cortex). These results suggest that gambling habits introduce significant changes in action preparation during decision-making following wins and losses.

1. Introduction

Evoking memories of past actions is a key process in human's ability to adapt to their environment. It usually involves the integration of cognitive (e.g., the maintenance and updating of relevant information) and affective/emotional processes, and it results in the ability to optimally anticipate the potential outcomes (e.g., gains versus losses) of a given decision (Bechara, 2005; Brevers, Bechara, Cleeremans, & Noël, 2013; Brevers & Noël, 2013; Damasio, 1996; Noël, Brevers, & Bechara, 2013a, Noël, Brevers, & Bechara, 2013b; Zelazo & Müller, 2002).

Some situations, however, require the individual to take some distance from memories of previous choice outcomes, and to focus exclusively on the current costs and benefits associated with available alternatives. Nevertheless, it has been repeatedly shown that individuals are more likely to persist in their choices when time and effort have been invested on it (i.e., the "escalation of commitment" or the "sunk-cost" effect; Thaler, 1980). For instance, at a supermarket, one is often more likely to keep waiting in the line he/she just chose for paying despite the others line moving faster. This type of decision bias also impacts monetary decision-making where choice outcomes are independent from each other, such as during gambling. Indeed, a systematic observation in gambling is that individuals are more prone to take risky choices following a loss, as compared to following a win (Ayton & Fischer 2004; Barkan & Busemeyer, 2003; Campbell-Meiklejohn, Woolrich, Passingham, & Rogers, 2008; Clark, Lawrence, Astley-Jones, & Gray, 2009; Croson & Sundali 2005; Gilovich, Vallone, & Tversky, 1985; Hytönen et al., 2014; Laplace, 1951; Paulus, Rogalsky, Simmons, Feinstein, & Stein, 2003; Rabin, 2002; Tversky & Kahneman, 1992; Xue, Lu, Levin, & Bechara, 2011). This behavioral pattern is commonly referred to as "loss-chasing" (Dickerson, 1984; Kahneman & Tversky, 2000; Tversky & Kahneman, 1981).

Recent functional magnetic resonance imaging (fMRI) shed some lights on potential cognitive and affective processes involved in the effect of prior outcomes on subsequent monetary decision-making. Specifically, it has been highlighted that decision-making after losing a gamble is associated with increased activation in a frontoparietal neural network, which includes the supramarginal gyrus, the superior, middle and inferior frontal gyri, the orbitofrontal and ventromedial prefontral cortex (Dong, Zhang, Xu, Lin, & Du, 2015; Losecaat Vermeer, Boksem, & Sanfey, 2014; Xue et al., 2011; Zeng, Zhang, Chen, Yu, & Gong, 2013). Thus, it

* Corresponding author at: Brain and Creativity Institute, University of Southern California, 3620A McClintock Avenue, 90089-2921, Los Angeles, CA, USA.
E-mail address: brevers@usc.edu (D. Brevers).

http://dx.doi.org/10.1016/j.biopsycho.2017.01.009
0301-0511/

appears that one's attempt to recover from prior losses involves the engagement of a brain network important for value encoding, the regulation of affect, and the guidance of subsequent choice behavior (Barber & Carter 2005; Bunge, Hazeltine, Scanlon, Rosen, & Gabrieli, 2002; Derrfuss, Brass, Neumann, & von Cramon, 2005; Derrfuss, Brass, & Yves von Cramon, 2004; Hare, Camerer, & Rangel, 2009; Rosenbloom, Schmahmann, & Price, 2012; Xue, Ghahremani, & Poldrack, 2008). By contrast, resisting "loss chasing" has been reported to be associated with increased activation within the anterior cingulate cortex, the insular cortex and the amygdala (Campbell-Meiklejohn et al., 2008; Xue et al., 2011), that is, brain regions involved in conflict monitoring and risk aversion (De Martino, Camerer, & Adolphs, 2010; Paulus et al., 2003; Rushworth, Walton, Kennerley, & Bannerman, 2004; Sokol-Hessner, Camerer, & Phelps, 2013; Samanez-Larkin, Hollon, Carstensen, & Knutson, 2008). With regard to risk-taking following a gain, it has been shown that the neural activity in the caudate and ventral striatum is higher when compared to decision-making after loss (Xue et al., 2011). Hence, deciding after winning activates reward and reinforcement learning processes (Daw, O'Doherty, Dayan, Seymour, & Dolan, 2006; Haruno & Kawato 2006; O'Doherty et al., 2004; Schultz, 2002; Tricomi, Delgado, & Fiez, 2004; Xue et al., 2008)). One possible explanation for this finding is that experiencing a win might decrease one's subsequent temptation to gamble, by "locking-in" the gain that he/she just obtained.

One gap of knowledge from prior brain-imaging studies is that the neural correlates of risk-taking following wins and losses have not been examined in individuals who are highly exposed to monetary risk-taking, such as poker players. Specifically, during poker playing, the individual could always learn from their opponents' strategy (e.g., in order to infer some betting patterns), but it is also critical for them to compute the risk of their decision based on the cards at hands, and also to disengage from recently experienced outcomes. In other words, poker players are often required to keep playing (or leave the game) based solely on the odds associated with their forthcoming choices. Hence, the ability to proficiently regulate one's emotions while playing—such as being able to cope with frustration that might be induced by previous losses—is an important part of success in poker (Browne, 1989; Laakasuo, Palomäki, & Salmela, 2014; Laakasuo, Palomäki, & Salmela, 2015; Palomäki, Laakasuo, & Salmela, 2013; Palomäki, Laakasuo, & Salmela, 2014). It follows that experienced poker players might be able to "let go" of unfavorable outcomes from previous actions, and consequently they might be better skilled at regulating themselves when facing monetary risky decisions (Laakasuo et al., 2014; Palomäki et al., 2013, 2014). Besides, previous neuroimaging studies on decision-making in gamblers have been undertaken with individuals suffering from gambling disorders and recruited from addiction treatment centers (Choi et al., 2012; van Holst, Veltman, Büchel, van den Brink, & Goudriaan, 2012) or did not control for gamblers' preferred type of gambling (e.g., poker vs. slot-machine; Balodis et al., 2012; Brevers et al., 2015a; Chase & Clark, 2010; Miedl, Fehr, Meyer, & Herrmann, 2010; Peters, Miedl, & Büchel, 2013; Power, Goodyear, & Crockford, 2012; van Holst, Chase, & Clark, 2014). This could have biased gambler participants' approach towards monetary risk-taking (Lorains et al., 2014; Turner, 2014). Hence, fundamental research is currently needed in order to get better grasp of the impact of frequent gambling on specific processes involved in decision-making.

In the present study, we aimed to examine how prior choice outcomes may influence the behavioral and neural activity of poker players' subsequent gambling choice, relative to non-gambler individuals. Since in a previous study we collected data from a sample of non-gamblers (Xue, Lu, Levin, & Bechara, 2010, [Xue et al., 2011]2011), the current study involved the collection a matching dataset from a sample of high-frequent poker players, and then comparing the two datasets. In the experimental task of the previous study (the Modified Cups Task; Weller, Levin, Shiv, & Bechara, 2007; Xue et al., 2010, 2011), participants were asked to decide whether or not to take a risky-choice based on the probability of winning, and also on the available win/loss ratio. This is consistent with the pattern of probabilistic monetary decision–making that characterizes poker playing. We hypothesized that frequent poker players would be better at disengaging themselves from their previous choice outcome, as compared to non-gambler controls. More specifically, on a behavioral level, we hypothesized that loss-chasing (i.e., higher proportion of risky choices after losing than after winning a gamble) would be lower in poker players than in controls. On a neural level, we hypothesized that controls would exhibit higher brain activations than poker gamblers while deciding to take a risk or not after having experienced a loss.

2. Materials and methods

2.1. Participants

Fifteen regular poker players (gender: 6 males, 9 females; age: mean = 24.67, median = 24, 25th = 20, 75th = 26; education level: mean = 15.31, median = 15, 25th = 12, 75th = 18) and 14 non-gambler controls participated in this study (gender: 7 females, 7 males; age: mean = 23.80, median = 23.5, 25th = 22, 75th = 25, education level: mean = 16.12, median = 17, 25th = 15, 75th = 18). The two-groups did not differ in age (Mann–Whitney U statistic = 101.50, $Z = -0.15$, $p = 0.88$), gender ($X^2 = 0.59$, $p = 0.72$) and level of education (Mann–Whitney U statistic = 87.00, $Z = -0.84$, $p = 0.45$). All participants gave informed consent to the experimental procedure, which was approved by the University of Southern California Institutional Review Board. One gambler participant was excluded from the analyses due to technical failure with the MRI-compatible button press box. Hence, our final sample consisted of fourteen frequent gamblers and fourteen controls.

Poker gamblers were recruited on the Internet through advertisement displayed on online forums for poker players based in Los Angeles. The ads asked for participants who "played poker frequently" to participate in a one-day study to explore factors associated with decision-making in poker gambling. An email-screening interview was conducted in order to examine gambling frequency, problem gambling severity, history of therapeutic intervention focused on gambling behavior, medical history (as assessed with an MRI screening form; see also Brevers, Noël, He, Melrose, & Bechara, 2015b), substance abuse (items taken from the Addiction Severity Index Short Form), episodes of major depression or other psychiatric disorders (see also Brevers et al., 2015b). Only high-frequency poker players were recruited in our study. Specifically, only individuals who reported playing poker at least than twice a week (over the last 18 months) were included in this study. None of the poker player participants reported a history of therapeutic treatment focused on gambling behavior or having suffered of any major psychiatric disorders.

Control participants were recruited by word of mouth from the community (see also Xue et al., 2011). They were free of neurological or psychiatric history, and gave informed consent to the experimental procedure. Medical history was taken via completion of an MRI screening form. All subjects were right handed and had normal or corrected-to-normal vision. Problem gambling severity was assessed the day of study with the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). All controls scored zero on the SOGS. Poker players' SOGS scores and information on their frequency of poker playing (per week) and minimum amount of money spent on poker (per week) is depicted in Table 1.