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Failure to utilize feedback causes decision-making deficits among excessive Internet gamers

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ABSTRACT

Internet gaming addiction (IGA) is an increasing mental health issue worldwide. Previous studies have revealed decision-making impairments in excessive Internet gamers (EIGs) with high symptoms of IGA. However, the role of feedback processing in decision-making deficits among EIGs remains unknown. The present study aimed to investigate the effect of feedback processing on decision-making deficits under risk among EIGs, using the Game of Dice Task (GDT) and a modified version of the GDT in which no feedback was provided. Twenty-six EIGs and 26 matched occasional Internet gamers (OIGs) were recruited. The results showed: (a) OIGs performed better on the original GDT than on the modified GDT (no feedback condition); however, EIGs performed similarly on both tasks; (b) EIGs and OIGs performed equally on the modified GDT; however, EIGs chose more disadvantageous options than OIGs on the original GDT; (c) EIGs utilized feedback less frequently on the original GDT relative to OIGs. These results suggest that EIGs are not able to utilize feedback to optimize their decisions, which could underlie their poor decision-making under risk.

1. Introduction

As the population of Internet users rapidly surges, Internet addiction has become an increasing mental health issue worldwide, raising public concerns (Young, 1998; Block, 2008). Some researchers even regard Internet addiction as the most rapidly growing addiction (Dong et al., 2012). Internet gaming addiction (IGA) is the most prevalent subtype of Internet addiction in many countries (Kuss and Griffiths, 2012), especially in China (Dong et al., 2013a), where over 330 million people play Internet games (China Internet Network Information Center, 2014). Excessive Internet gaming can result in severe consequences, such as a loss of interest in other activities, reduced academic performance, jeopardized interpersonal relationships, and poor health (Petry et al., 2014). As IGA demonstrates behavioral and neural similarities with drug addictions, it is classified as a behavioral addiction (van Holst et al., 2010). Moreover, the American Psychiatric Association included IGA in the DSM system as a topic requiring additional research (American Psychiatric Association, 2013).

The criteria for IGA, such as excessively gaming online at the cost of other important life activities or playing longer than intended, provide several direct and indirect references to maladaptive decision-making in daily life (Dong et al., 2013b; Petry et al., 2014). However, only a few studies have experimentally examined decision-making abilities among individuals with symptoms of IGA or Internet addiction in general, and the findings from these studies are mixed. For example, Pawlikowski and Brand

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(2011) observed that excessive Internet gamers (EIGs) showed impaired decision-making abilities on the Game of Dice Task (GDT; Brand et al., 2005). Moreover, using the modified version of Iowa Gambling task (IGT; Bechara et al., 1994), Sun et al. (2009) observed that excessive Internet users generally made more disadvantageous decisions and performed worse than healthy controls. This result is consistent with a study showing that individuals with Internet addiction had deficits in decision making as measured by the IGT (Xu, 2012). However, Ko et al. (2010) reported that college students with Internet addiction performed better on the IGT than healthy controls.

A remaining question is why many people who play Internet games for recreation do not develop IGA, whereas a subset of individuals become addicted to Internet games and persist in playing online even when they have experienced negative consequences of excessive Internet gaming (e.g., impaired academic performance, problems with interpersonal relationships). One possible cause might be a reduced ability to process feedback. Feedback processing is one of the core components of decision-making (Paulus, 2007). Since decision-making is an adaptive process in which individuals have to update and integrate information of potential options, feedback processing and regulation are crucial for optimal decision-making (Weber and Johnson, 2009). Brand (2008) found that healthy volunteers utilize feedback processing to significantly improve their decision-making performance, whereas reduced ability to utilize feedback to optimize decisions has been found in methadone-maintained opiate users (Ersche et al., 2005), patients with opiate dependence (Brand et al., 2008), young adults at risk for stimulant dependence (Stewart et al., 2013) and women with binge eating disorder (Svaldi et al., 2010). However, the role of feedback processing in decision making among EIG with high symptoms of IGA has not been investigated previously.

In the current study, our purpose was to expand upon previous studies and clarify the role of feedback in decision-making among EIGs with high symptoms of IGA. For this purpose, all participants were administered the original GDT (Brand et al., 2005) and a modified version of the GDT (Brand et al., 2008) for which no feedback was provided. We chose the GDT rather than the widely used IGT in this study for two reasons: first, explicit possibilities for gains and losses are not provided in the IGT. Research suggests that EIGs with high symptoms of IGA generally know the consequences of excessive Internet gaming in real life (Pawlikowski and Brand, 2011). For this reason, a decision-making task with explicit winning probabilities and an explicit number of gains and losses, such as the GDT, may be a more sensitive instrument to assess decision-making in this population. Second, the IGT is a relatively complex task that involves many cognitive processes, such as working memory, response inhibition, and rule detection (Dunn et al., 2006), which might make it difficult to pinpoint the specific mechanism contributing to decision-making deficits among EIGs.

Based on previous findings of a reduced ability to utilize feedback to guide decision-making among individuals with other types of addiction (Ersche et al., 2005; Brand et al., 2008) as well as findings of impaired decision-making performance on the original GDT among EIGs (Pawlikowski and Brand, 2011), we hypothesized that: (1) EIGs would perform worse on the original GDT than occasional Internet gamers (OIGs); and (2) EIGs would fail to utilize feedback from previous phrases to optimize their decision-making performance.

2. Methods

2.1. Participants

Fifty-two college students (26 EIGs and 26 OIGs) were recruited from universities by online advertisement. All participants were right-handed adults. Given the higher prevalence rates of IGA among men (Yen et al., 2012; Ko et al., 2014), in addition to the possibility of gender-related differences that might add additional statistical within-group variance, only males were included in this study. Participants who reported a history of neurological or psychiatric disease as well as any other type of addiction, or current use of any psychotropic medication were excluded. After complete explanation of the study procedure, participants gave informed consent to the experimental procedure, which was approved by the Beijing Normal University institutional review board. Demographic characteristics for all participants are presented in Table 1.

Participants were selected based on their scores on the Chen Internet Addiction Scale (CIAS; Chen et al., 2003) and the amount of time that they spent on Internet gaming each week. Participants were classified as EIGs if they: (1) scored higher than 67 on the CIAS (Ko et al., 2009); (2) played Internet games for at least 14 h a week; and (3) spent the majority of their time (i.e. > 50%) of Internet use on Internet games and kept this intensive use over one year. OIGs played Internet games less than 5 h per week and did not meet CIAS requirements for IA within one year. Thus, EIGs spent significantly more time on Internet gaming weekly relative to OIGs (Table 1). The Internet games that participants played include Defense of the Ancients (12 EIGs and 11 OIGs), League of Legends (5 EIGs and 4 OIGs), World of Warcraft (2 EIGs and 4 OIGs), and Cross Fire (3 EIGs and 5 OIGs). In addition, two EIGs and 2 OIGs played both Defense of the Ancients and League of legends, and 2 EIGs played both Defense of the Ancients and World of Warcraft.

All participants were paid 30 yuan (≈ $5) for their participation. In addition, to motivate participants to try their best on the tasks, they were informed before the tasks that the 10 best-performing participants would be rewarded with an additional 10 yuan.

2.2. Instruments

2.2.1. The Chen Internet addiction scale

The CIAS consists of 26 items, assessing 5 dimensions of IA symptoms: compulsive use, withdrawal, tolerance, problems of interpersonal relationships, and time management. For each item, a graded response is selected from 1 = "Rarely" to 4 = "Always", so that the total score ranges between 26 and 104. The reliability and validity of the CIAS among college students has been demonstrated previously (Chen et al., 2003).

Table 1
Demographic, Internet use lifetime, the CIAS scores and time spent on Internet gaming for EIGs and OIGs.

	EIGs (n=26) mean ± S.D.	OIGs (n=26) mean ± S.D.	t value
Age	22.54 ± 2.10	22.00 ± 2.15	0.91
Years of education	15.85 ± 1.78	15.31 ± 1.74	1.10
Internet use lifetime (in years)	9.27 ± 2.84	9.58 ± 2.75	−0.40
CIAS scores	77.96 ± 7.34	50.46 ± 10.04	11.28**
Time spent on Internet gaming per week (in hours)	17.02 ± 4.82	0.87 ± 0.47	17.01**

*$P < 0.05$; **$P < 0.01$.
S.D. = standard deviation; EIGs = excessive Internet gamers; OIGs = occasional Internet gamers; GDT = Game of Dice Task.

2.3. Original Game of Dice Task and modified Game of Dice Task

The computerized GDT (Brand et al., 2005) was used to assess decision-making under explicit risk condition. In this task, participants start with a sum of 1000 yuan and are instructed to increase this amount using throws of a virtual dice. Prior to each throw of the dice, they are instructed to choose a dice number, each of which is associated with different probabilities for gains and losses (winning probabilities 1:6, 2:6, 3:6 and 4:6 and gains/losses 1000 yuan, 500 yuan, 200 yuan and 100 yuan, respectively). If the thrown number of the dice is congruent with the selected dice number or any of the combination of numbers, participants win the specified amount. If it is not, they lose the same amount of money. For example, if a participant chose the combination of 1 and 2 and the number of the dice thrown was 1 or 2, then the participant would win 500 yuan (and the winning possibility is one third). However, if the number of the dice thrown was not 1 or 2, the participant would lose 500 yuan. Because winning possibilities are lower than 50%, the one single number alternative and the combination of two numbers are considered disadvantageous alternatives. By contrast, the three- and the four-number combinations are considered advantageous alternatives as the winning probabilities are higher than or equal as 50% (Brand et al., 2005). For further details on the GDT, see Brand et al. (2005)

In the modified GDT, all feedback associated features are removed (Brand, 2008). In this task, the subjects do not know the number thrown in each trial, and the monetary balance is fixed to the starting capital. Thus, participants do not know the result of each trial. All other aspects of the task are similar to the original GDT. At the end of the task, the final balance is shown to participants.

2.4. Study procedure

After complete description of the experimental procedure, each participant completed a brief self-report questionnaire of basic demographic and clinical information (e.g., age, years of education, psychiatric disease history), which took approximately 10 min. The order of the tasks was counterbalanced between the participants in each group; 13 EIGs and 13 OIGs were randomly selected to complete the modified GDT first, and the remaining 26 participants completed the original GDT prior to the modified GDT.

2.5. Statistical analysis

GDT performance was assessed using a net score (number of disadvantageous choices – number of advantageous choices), with a positive net score indicating good performance, as in previous studies; e.g., (Brand et al., 2005). In addition, the final balance was also recorded as an index of GDT performance. According to previous studies (Brand, 2008; Brand et al., 2009a), the effect of feedback use on GDT performance is determined by directly comparing subjects' performance on the original GDT with their performance on the modified GDT. If subjects profit from feedback processing, they will achieve significantly higher net scores or gain more money (final balance) on the original GDT than on the modified GDT. If subjects do not profit from feedback, they will perform similarly on both GDT tasks. Furthermore, in order to assess the use of feedback on the original GDT, the following dependent variables were also analyzed: (1) frequency of shifting to an advantageous alternative after a loss (negative feedback) following a disadvantageous option and (2) frequency of persisting in an advantageous alternative after positive feedback (Brand et al., 2009b; Svaldi et al., 2010).

All statistical analyses were conducted with the SPSS version 20.0 for Windows. First, independent *t*-tests were conducted to test for differences between EIGs and OIGs for demographic characteristics, CIAS score and weekly time for Internet gaming. Second, to analyze participants' decision-making performance and feedback processing, analyses of variance (ANOVAs) with repeated measures was conducted with the GDT version as the within-subject factor and the group as the between-subject factor; the GDT net score and the final balance were used as dependent variables. Third, independent *t*-tests were used to analyze the use of negative and positive feedback on the original GDT between EIGs and OIGs. In addition, to investigate the association between GDT performance and Internet addiction severity, Pearson correlations were conducted. Two-tailed tests were performed for all analyses, and results were considered significant at $P<0.05$.

3. Results

Findings from comparisons of demographic characteristics, including CIAS scores and weekly time spent on Internet gaming, are presented in Table 1. The two groups of participants did not differ in age, years of education or years of Internet use; however, the EIG group had significantly higher CIAS scores, $t=11.28$, $P<0.001$; and spent significantly more time on Internet gaming weekly, $t=17.01$, $P<0.001$; relative to OIG.

The GDT net score and the mean final balance in both the original and the modified GDT for both participant groups are shown in Table 2. With the GDT net score as a dependent variable, a repeated ANOVA with GDT versions as within-subject factor and groups as between-subject factor revealed a significant main effect of group, $F\ (1,\ 50)=9.62$, $P<0.01$, partial $\eta^2=0.16$; a GDT version effect, $F\ (1,\ 50)=12.98$, $P<0.01$, partial $\eta^2=0.21$; and a significant interaction between group and GDT version, $F\ (1,\ 50)=9.72$, $P<0.01$, partial $\eta^2=0.16$. Because of the significant interaction between group and GDT version, simple effect analysis for group was conducted. As shown in Fig. 1, although both groups performed equally on the modified GDT, $F\ (1,\ 50)=2.46$, $P=0.12$, partial $\eta^2=0.05$. EIGs achieved a significantly lower net score on the original GDT than OIGs, $F\ (1,\ 50)=18.54$, $P<0.001$, partial $\eta^2=0.29$. Moreover, simple effect analysis for the GDT version showed that OIGs performed much better on the original GDT than on the modified GDT, $F\ (1,\ 50)=17.39$, $P<0.001$, partial $\eta^2=0.27$. However, among EIGs, performance on the original GDT were similar to that on the modified GDT, $F\ (1,\ 50)=0.11$, $P=0.75$, partial $\eta^2<0.01$. These results suggest that EIGs and OIGs performed equally on the modified GDT with no feedback; however, on the original GDT, OIGs utilized feedback to optimize their decisions and improved their performance; whereas EIGs performed equally poorly on the original and modified GDTs (see Fig. 1).

A repeated measures ANOVA was also conducted with the final balance as the dependent variable and revealed similar results. There were significant main effects of the group, $F\ (1,\ 50)=11.18$, $P<0.01$, partial $\eta^2=0.18$; and GDT version on the final balance, $F\ (1,\ 50)=8.99$, $P<0.01$, partial $\eta^2=0.15$. There was also a significant interaction between group and GDT version, $F\ (1,\ 50)=7.65$, $P<0.01$, partial $\eta^2=0.13$. Further, the simple effect analyses showed that EIGs and OIGs did not differ in the final balance on the modified GDT, $F\ (1,\ 50)=2.18$, $P=0.15$, partial $\eta^2=0.04$; however, EIGs accumulated much less money than OIGs on the original GDT, $F\ (1,\ 50)=18.79$, $P<0.001$, partial $\eta^2=0.27$. Moreover, OIGs improved their final balance significantly on the original GDT compared to the modified GDT, $F\ (1,\ 50)=16.61$, $P<0.001$, partial

Table 2
Decision-making performance on the original GDT and the modified GDT for EIGs and OIGs.

	EIGs ($n=26$) mean ± S.D.	OIGs ($n=26$) mean ± S.D.	t value
Original GDT net score	0.00 ± 9.31	10.31 ± 6.97	4.52^{**}
Modified GDT net score	-0.46 ± 9.98	3.92 ± 10.17	1.57
Original GDT final balance	-2207.69 ± 2273.49	38.46 ± 1346.43	4.34^{**}
Modified GDT final balance	-2269.23 ± 2033.67	-1492.31 ± 1781.44	1.47

$^{*}P<0.05$; $^{**}P<0.01$.
S.D. = standard deviation; EIGs = excessive Internet gamers; OIGs = occasional Internet gamers; GDT = Game of Dice Task.

$\eta^2=0.25$. However, EIGs did not accrue different amounts of money on the two tasks, F (1, 50)=0.03, $P=0.89$, partial $\eta^2<0.01$. Combined, these results suggest that OIGs improved their decision-making performance in the presence of feedback. In contrast, EIGs failed to utilize feedback to accrue more money even under explicit risk conditions.

To further confirm our findings, we compared EIGs' and OIGs' use of feedback on the original GDT. As only 19 OIGs and 23 EIGs selected disadvantageous options and then received negative feedback, only these 42 subjects were included in this comparison. A two sample t-test showed that EIGs shifted to advantageous options after losing by choosing the disadvantageous options less frequently, $t=-5.13$, $P<0.001$. The analysis of frequency of using positive feedback to persist on the advantageous alternatives revealed that EIGs chose less advantageous options after winning in previous trial than did OIGs, $t=-3.14$, $P<0.01$. The results of the use of feedback on the original GDT are shown in Table 3.

Internet addiction severity, as measured by the CIAS, was negatively correlated with both the original GDT net score, $r=-0.52$, $P<0.001$, and the original GDT final balance, $r=-0.52$, $P<0.001$. However, correlations between modified GDT indexes and Internet addiction severity were not significant. Furthermore, none of the correlations between lifetime Internet use and the four decision-making variables reached a level of significance. The combined results suggest that the more subjects are addicted to Internet games, the less they utilize feedback to guide their choices.

4. Discussion

To our knowledge, this is the first study focusing specifically on the role of feedback processing in decision-making under risk among EIGs with high symptoms of IGA. EIGs performed significantly worse than OIGs on the original GDT (feedback condition), but did not differ from OIGs in performance on the modified GDT (no feedback condition). Among OIGs, performance was significantly better for the original GDT than for the modified GDT. In contrast, no performance differences in original versus modified GDT performance were observed among EIGs. Overall, these data suggest that OIGs utilized feedback to optimize their choices (resulting in higher GDT net scores) whereas individuals with EIGs did not.

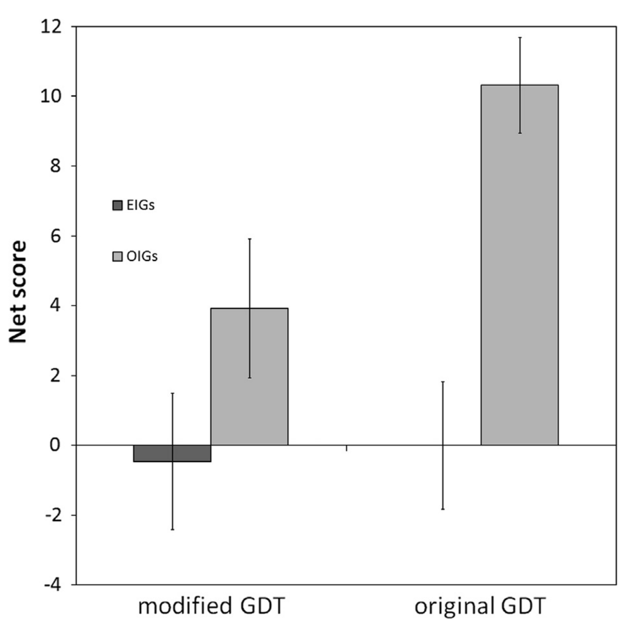

Fig. 1. Performance on the original GDT and the modified GDT by EIGs and OIGs. OIGs achieved higher net score (Four Numbers+Three Numbers – Two Numbers – One Number) on the original GDT than on the modified GDT. However, EIGs gained almost equal net score on both tasks. Error bars reflect standard errors. EIGs=excessive Internet gamers; OIGs=occasional Internet gamers; GDT=Game of Dice Task.

Consistent with our first hypothesis, EIGs with high symptoms of IGA showed impaired decision-making ability on the original GDT. This finding is consistent with results from a previous study which also used the GDT to investigate decision making among EIGs (Pawlikowski and Brand, 2011). EIGs selected significantly more disadvantageous alternatives than OIGs, as indicated by the net score and the final balance. Disadvantageous options are associated with large amounts of money but lower winning possibilities, generally leading to ultimate losses. The present findings suggest that EIGs may prefer immediate high rewards despite negative long-term consequences, resulting in worse decision-making under risk. In addition, Internet addiction severity was negatively correlated with the overall performance on the original GDT, suggesting that the ability to utilize feedback may be related to the severity of IGA.

On the modified GDT (no feedback condition), EIGs and OIGs accrued similar net scores and amounts of money (final balance). Although both groups performed poorly on the modified GDT, OIGs performed slightly better than EIGs (Fig. 1). This finding is comparable to a previous report of marginally better performance on the modified GDT among healthy control participants in comparison to patients with alcoholic Korsakoff's syndrome (Brand et al., 2009b), possibly suggesting similarities across addictive disorders. Since explicit rules were provided in the modified GDT, subjects were still able to develop and employ strategies without feedback. The worsened performance on the modified GDT among EIGs might reflect deficits in other cognitive components of decision-making, such as impairments in executive functions essential for strategy development (Brand et al., 2009a). This hypothesis requires further clarification in future studies.

Comparisons between the original GDT and the modified GDT within both groups demonstrated that OIGs greatly benefited from feedback, suggesting appropriate utilization of feedback processing in guiding decision making strategies, resulting in selection of more advantageous options and overall improvements in task performance on the original GDT. In contrast, during performance of the original GDT, EIGs did not adjust their behavior in the presence of negative feedback and instead persisted in disadvantageous choices. Taken together, these results indicate that EIGs fail to utilize feedback to guide decision-making processes under risk.

Our finding of improved performance on the original (feedback condition) versus modified (no feedback condition) GDT among OIGs are consistent with those from previous studies conducted among healthy individuals (Brand, 2008; Brand et al., 2009a). Our finding of a failure to utilize feedback to improve decision-making among EIGs is similar to that previously reported among clinical patients with alcoholic Korsakoff's syndrome (Brand et al., 2009b). However, to our knowledge, this is the first study to investigate the effects of feedback processing by directly comparing performance on the modified versus original GDT among individuals with addiction without a co-occurring neurological condition (e.g., Korsakoff's syndrome). Previous studies using the original GDT have found reduced use of positive and negative feedback among patients with opiate dependence (Brand et al., 2008), and women with binge eating disorder (Svaldi et al., 2010). Therefore, we further analyzed feedback processing on the original GDT. Our findings of a reduced use of both negative and positive feedback among EIGs (in comparison to OIGs) are consistent with these previous findings, and suggest possible commonalities for decision-making deficits across addictive disorders.

In comparison to OIGs, EIGs more often persisted in disadvantageous choices even after heavy losses. Most people are loss averse,

Table 3
The use of feedback on the original GDT for EIGs and OIGs.

	EIGs (n=26) mean ± S.D.	OIGs (n=26) mean ± S.D.	t value
Used negative feedback after a disadvantageous choice for a shift to an advantageous alternative (in %)	49.10 ± 18.25 (n=23)	79.96 ± 20.71 (n=19)	-5.13^{**}
Used positive feedback after an advantageous choice for persisting in an advantageous alternative (in %)	51.43 ± 33.23 (n=26)	76.90 ± 24.72 (n=26)	-3.14^{**}

$^{*}P<0.05$; $^{**}P<0.01$.
S.D.=standard deviation; EIGs=excessive Internet gamers; OIGs=occasional Internet gamers; GDT=Game of Dice Task.

and they tend to reject risk unless the amount of gain is much greater than that of loss. The avoidance of loss is regarded as critical for survival (Kahneman and Tversky, 1979; Tom et al., 2007), whereas reduced loss aversion and elevated risk-seeking are hypothesized to contribute to addiction vulnerability (Bickel and Marsch, 2001; Peters et al., 2011). The present finding is also comparable with previous studies showing insensitivity to negative feedback with loss among individuals with Internet gaming addiction (Dong et al., 2013b) and with Internet addiction in general (Xu, 2012) using different decision-making tasks. Furthermore, insensitivity to negative feedback within the context of heavy losses may reflect one of the core symptoms of IGA – continued Internet gaming despite real-world negative consequences.

Reduced use of positive feedback to guide continued advantageous decision-making was also observed among EIGs, possibly suggesting increased sensitivity to large reward possibilities despite more advantageous alternatives. Researchers have proposed that hypersensitivity to immediate high rewards contributes to addiction (Bechara et al., 2002; Bechara, 2005). Importantly, a recent neuroimaging study indicated that enhanced reward sensitivity is a key feature of IA rather than other types of addictions (Dong et al., 2013a). The current findings provide additional support for this hypothesis and also suggest a possible mechanism via which EIGs persist in playing Internet games (which are associated with immediate hedonic rewards), and neglect other less immediately rewarding activities, such as academic work.

Our findings emphasize the significant contribution of feedback processing to complex decision-making processes among EIGs with high symptoms of IGA. Failure to utilize feedback may reflect a disorder of the reinforcement learning system among EIGs with high symptoms of IGA. Feedback processing is actually a learning mechanism in decision-making. Reinforcement learning is an adaptive process in which human beings utilize previous experiences to improve the outcomes of future choices. Therefore, learning from feedback plays an important role in decision-making (Lee et al., 2012). Substance abuse and dependence are often associated with abnormal learning and memory functions (Hyman et al., 2006). However, learning and memory functions among individuals with symptoms of IGA remain poorly understood and more studies should investigate learning and memory systems and their impact on decision-making among excessive Internet gamers.

Another possible explanation that could give rise to reduced ability to utilize feedback in IGA is impaired activation of somatic markers. According to somatic marker hypothesis (Damasio, 1994), feedback can generate somatic signals, which help guide individuals' decision in the advantageous direction. Using skin conductance response (SCR) as an index of somatic state activation, researchers have observed deficient SCRs in patients with substance dependence (Bechara and Damasio, 2002) and pathological gamblers (Goudriaan et al., 2006). However, impaired activation of somatic markers has more impact on decision-making under ambiguity than those made under risky condition (Brand et al., 2006). Whether activation of somatic markers among EIGs is impaired, and how this might interact with feedback processing, require further study.

This preliminary study has a few limitations. First, the samples in the current study were relatively small. Second, our recruitment of only male college students limits the generalizability of our findings. Although college students are one of the most susceptible populations to IGA (Chou et al., 2005), more studies are necessary to explore the association between feedback processing and IGA among non-college students and within clinical samples (e.g., treatment-seeking individuals). Moreover, the control group in current study also played Internet games occasionally, and had a relatively high mean CIAS score. However, we were interested in differences between individuals with some exposure to Internet gaming (OIG group) who had not developed IGA, in comparison to those who had (EIG group). It is likely that studies using control groups without any history of Internet gaming might yield more robust and significant results. A further limitation is that no assessment of intelligence was conducted in this study. However, all subjects recruited in our study were college students, suggesting high intelligence. Finally, the subjects were not formally examined for co-morbid psychopathologies such as depression or anxiety, and the influence of these variables on decision-making among EIGs with high symptoms of IGA should be clarified in future studies.

In summary, EIGs demonstrated impaired decision-making under risk on the original GDT. Furthermore, whereas OIGs performed better on the original GDT compared with the modified GDT, EIGs performed equally on both tasks. These results indicate that failure to utilize feedback to optimize decision-making may contribute significantly to poor decision-making under risk among EIGs. Future intervention studies aimed at ameliorating Internet addiction among college students should focus on how to improve individuals' ability to utilize feedback information when they make decisions related to Internet use.

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