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Greater tolerance to losses in sensation seeking: Evidence from probability and delay discounting

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ABSTRACT

Background: Sensation seeking is a behavioral endophenotype of substance use and is associated with abnormalities in financial reward processing. Previous research suggests that high sensation seekers (HSS) relative to low sensation seekers (LSS) show either an enhanced sensitivity to financial rewards or a reduced sensitivity to financial punishments. However, there are few studies investigating the valuation of financial rewards and punishments as a function of delivery probability and delay, two important aspects of reward processing that influence the valuation.

Methods: We administrated a probability discounting task and a delay discounting task to 56 HSS and 57 LSS selected from a large sample. Each task was crossed with two factors: valence (gain vs. loss) and amount (¥1000 vs. ¥50000).

Results: For the probability discounting task, HSS discounted probabilistic losses but not gains more steeply than LSS, irrespective of the amount of outcome. For the delay discounting task, HSS discounted delayed losses more steeply than LSS, for the large but not small amount condition. In contrast, both groups exhibited comparable discounting rates for gains across the two amount conditions. These results remained significant when impulsivity levels were controlled for.

Conclusions: Together, our data strengthen the argument that the dysfunctional valuation in sensation seeking is valence specific, which may be driven by a weaker avoidance system, rather than by a stronger approach system.

1. Introduction

The personality trait of sensation seeking is defined as “the tendency to take risks for varied, novel, complex and intense sensations and experiences” (Zuckerman, 1994). It has been in recent years regarded as a potential endophenotype of various risk-taking behaviors (Benjamin et al., 2001; Gottesman and Gould, 2003; Mann et al., 2017), including risky driving (Jonah, 1997), physical risk sports (Ruedl et al., 2012), promiscuous sexual activity (Hoyle et al., 2000), aggressive and unsocialized behaviors (Wilson and Scarpa, 2011), excessive gambling (Harris et al., 2015), and especially substance use (Bardo et al., 2007). One central issue is to unveil the psychological features giving rise to these sensation-seeking behaviors in order to promote the development of more targeted and efficient interventions (Perry et al., 2011; Tomko et al., 2016).

Risk taking is a complex construct that can be broadly defined as voluntary participation in behaviors that may be high in subjective desirability but with potential harm or loss (Geier and Luna, 2009; Zuckerman, 2007). For sensation seeking, the following question arises: Are high sensation seekers (HSS) more susceptible to risk-taking behaviors than low sensation seekers (LSS) because they are associated with increased desires for rewards or because they are more likely to ignore negative consequences? Previous research provides evidence for both. On one hand, traditional theories regard sensation seeking as an expression of a hyperactive approach system (Zuckerman, 1990, 1994) whereby the rewards of “varied, novel, complex, and intense sensations and experiences” outweigh the possible negative consequences of engaging in sensation-seeking activities. HSS relative to LSS exhibit greater subjective rewarding effects of psychostimulants such as alcohol (Fillmore et al., 2009) and d-amphetamine (Kelly et al., 2006; Stoops et al., 2007; White et al., 2006), more sustained electrophysiological responses to novel stimuli (Zheng et al., 2010), as well as enhanced

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brain activation in response to monetary rewards (Kruschwitz et al., 2012) and emotionally high-arousal stimuli (Joseph et al., 2009). On the other hand, other theories emphasize that sensation seeking is driven by a hypoactive avoidance system (Lang et al., 2005; Lissek et al., 2005). HSS versus LSS show blunted autonomic responses to threatening (Lissek and Powers, 2003) and aversive (Lissek et al., 2005) stimuli, and reduced brain responses to errors (Santesso and Segalowitz, 2009; Zheng et al., 2014), monetary losses (Kruschwitz et al., 2012), as well as stimuli with physical (Zheng et al., 2015) or monetary (Zheng and Liu, 2015) risk. In sum, it seems that motivational processing in sensation seeking is associated with either an enhanced sensitivity to desired outcomes or a decreased sensitivity to adverse consequences. Here, the current study focuses on the valuation (subjective value) of reward and punishment in sensation seeking, which has been ignored in previous research.

The valuation during decision making can be tested using both the delay and probability discounting tasks. Delay discounting refers to the decrease in the subjective value of an outcome as the delay until its receipt increases, whereas probability discounting refers to the decrease in subjective value as the odds against its receipt increases (Rachlin et al., 1991). In literature, delay discounting has mainly been regarded as an index of impulsive decision making, while probability discounting is mainly associated with risky decision making. Despite the similarity in the form of delay and probability discounting functions (for a review, see Green and Myerson, 2004), emerging evidence indicates a dissociation between delay discounting and probability discounting. For example, they are affected by the amount of choice in opposite directions such that larger delayed rewards are discounted less steeply than smaller delayed rewards whereas larger probabilistic rewards are discounted more steeply than smaller probabilistic rewards (Green et al., 1999; Mitchell and Wilson, 2010). Both delay and probability discounting have been proposed as underlying factors for various risk-taking behaviors, such as sexual risk taking (Lawyer and Mahoney, 2017), gambling (Holt et al., 2003), especially substance abuse as diverse as cigarettes (Reynolds et al., 2004), alcohol (Petry, 2001), cocaine (Bickel et al., 2011), and heroin (Kirby et al., 1999). Interestingly, these risk-taking behaviors, as noted above, can be predicted by sensation seeking. In this regard, it is possible that HSS and LSS should differ on the degree to which probabilistic and delayed outcomes are discounted.

To our knowledge, few studies examined the relationship between discounting and sensation seeking (Mitchell, 1999; Ostaszewski, 1996, 1997). In these previous studies, HSS and LSS showed comparable discounting rates of delayed monetary rewards (Ostaszewski, 1996, 1997), though higher scores on disinhibition, one facet of sensation seeking, were associated with greater delay discounting rates across cigarette smokers and non-smokers (Mitchell, 1999). However, individual differences in sensation seeking were observed with probability discounting, such that HSS discounted probabilistic rewards less steeply than LSS for large amounts but not small amounts (Ostaszewski, 1997). These findings indicate that sensation seeking is more associated with dysfunctional valuation of rewards in terms of delivery probability than that in terms of delivery delay. However, it remains unclear whether this dysfunctional valuation can be expanded to losses. Abundant research has demonstrated that discounting for gains is different from that for losses. For instance, both delayed and probabilistic losses are discounted less steeply than the same amount of delayed and probabilistic gains, which is referred to as the sign effect or the gain-loss asymmetry (Benzion et al., 1989; Thaler, 1981). Moreover, whereas amount has opposite effects on the extent to which delayed and probabilistic gains are discounted, little or no amount effect was observed on the discounting of either delayed or probabilistic losses (Estle et al., 2006; Green et al., 2014; Mitchell and Wilson, 2010). The valence asymmetry, together with the asymmetric amount effect, indicates that the cognitive processes underlying the subjective value of an outcome do not function identically for gains and losses (Kahneman and Tversky, 1979).

The present study examined whether HSS differ from LSS in performance on the discounting of probabilistic losses similar to the group differences in discounting observed with probabilistic rewards. Such a comparison would provide clarity as to whether sensation seeking is driven by a stronger approach system or by a weaker avoidance system, or by both. Another goal is to examine the amount effect on discounting in sensation seeking. The present study is the first to examine the gain-loss asymmetry in sensation seeking during both a probability discounting task and a delay discounting task. It is also the first to examine the effects of amount on the gain-loss asymmetry in sensation seeking with discounting tasks. Based on the two different frameworks outlined above, different hypotheses were derived. If sensation seeking is more related to a hyperactive approach system, then HSS relative to LSS should show steeper discounting for monetary rewards. Alternatively, if this trait is more associated with a hypoactive avoidance system, then shallower discounting for monetary losses should be observed for HSS relative to LSS. Moreover, according to the optimal arousal theory (Zuckerman, 1969, 1984), HSS relative to LSS need more intense sensations to reach their higher optimal level. It is therefore hypothesized that sensation-seeking related differences would be present in choices with high amounts, rather than those with small amounts.

2. Material and methods

2.1. Participants

One hundred and thirteen young adults were selected as participants based on their scores on the Sensation Seeking Scale Form V (SSS-V; Zuckerman et al., 1978). The SSS-V includes four subscales (10 items for each subscale): thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility. Summing the four subscales results in an overall sensation-seeking score. Reliability and validity of this scale have been proven to be good in Chinese culture (Wang et al., 2000). The SSS-V was administered initially in a university student sample (N = 443, 307 females and 136 males). Respondents scoring in the top quartile of the distribution were assigned to high sensation-seeking group, whereas those in the bottom quartile to low sensation-seeking group. The grouping criteria were applied within females and males separately due to the gender imbalance in our sample. Potential participants were subsequently invited randomly from the two groups, respectively. Additional recruitment criteria consisted of: (1) normal or correct-to-normal visual acuity; (2) right-handed habit; (3) no history of neurological or psychiatric disorders; and (4) no history of substance dependence, including cigarette, alcohol, caffeine, and drugs. As a result, the final sample consisted of 56 HSS and 57 LSS. Both groups also completed the Barratt Impulsiveness Scale Version 11 (BIS-11, Patton et al., 1995). Participants provided a signed informed consent prior to the experiment and received payment of ¥30 for their participation but no actual money for their discounting task performance. This research was approved by the Ethical Committee of Dalian Medical University in accordance with the Declaration of the 1964 Helsinki.

2.2. Procedure

Each participant completed two types of computerized discounting tasks with hypothetical amounts of money (Du et al., 2002), a probability discounting task and a delay discounting task, in a counterbalanced order. Each task was crossed with two factors of valence (gain vs. loss) and amount (¥1000 vs. ¥50000), resulting in four conditions for each task. The order of the four conditions was randomly determined.

In the probability discounting of gain task, participants made seven consecutive choices between a certain gain and a fixed, larger gain (either ¥1000 or ¥50000) that could be received with one of six different probabilities (95%, 75%, 50%, 30%, 10%, and 5%;

corresponding odds against: 0.053, 0.333, 1.0, 2.333, 9.0, and 19.0). The amount of the certain gain was adjusted across the seven choices. The first choice was always between the probabilistic gain and a certain gain whose amount was half that of the probabilistic gain (i.e., ¥1000 with 95% chance vs. ¥500 for sure). For each of the six subsequent choices, the amount of the certain gain was adjusted based on participants' previous choice. Specifically, if they chose the certain gain, then the amount of the certain gain during the next choice would be decreased; if they chose the probabilistic gain, then the amount of the certain gain during the next choice would be increased. The first adjustment was half of the difference between the certain and probabilistic gains, and the adjustment for subsequent choices was half of the previous adjustment. Based on this algorithm, the amount of the certain gain that would appear on the eighth choice was used as an estimate of the subjective value of the probabilistic gain. The probability discounting of loss task was similar except that choices were made between a loss that occurred for sure and a fixed, larger loss that was delivered with one of six different probabilities, and that the adjusting-amount algorithm was run using a reverse rule to adjust certain losses.

In the delay discounting task, participants made seven consecutive choices between a gain/loss that was available immediately and a fixed, larger gain/loss (either ¥1000 or ¥50000) that was delayed by one of seven periods of time (1-week, 1-month, 6-months, 2-years, 5-years, 10-years, and 25-years). The amount of the immediate gain/loss was adjusted across the seven choices using an adjusting-amount algorithm analogous to the one used for the probability discounting task, in order to estimate the subjective values of delayed gains/losses.

To prevent participants from making errors that could lead to inaccurate estimates of their subjective values, they were provided with an opportunity to restart the procedure if they made a choice that they were not happy with at any one of the consecutive seven choices. Moreover, in order to discriminate the probabilistic and delay discounting tasks, participants were informed that probabilistic gains/losses would be received immediately in the probability discounting task, whereas delay gains/losses would be delivered with a 100% probability in the delay discounting task. Prior to the formal experimental tasks, participants performed 28 choices with different probabilistic levels or delayed periods and amounts to familiarize themselves with the procedure.

2.3. Data analysis

To assess discounting for delayed and probabilistic outcomes, area under the discounting curve (AUC) was calculated separately for each participant for small and large gains and losses. Specifically, the AUC calculates the areas under the curve created by indifference points at different probabilistic or delayed levels and takes on values from zero to one, with a greater value indicating a greater preference for probabilistic/delayed outcomes (Myerson et al., 2001). The measure requires no assumptions about theoretical discounting models and is therefore not affected by quality of model fit. Furthermore, it is suitable for parametric statistics as the AUC values tend to be more normally distributed than discounting function parameters (e.g., k or h values). In the current study, AUC values of the probability discounting task and the delay discounting task were analyzed separately using a repeated-measures analysis of variance (ANOVA), with group (HSS vs. LSS) as a between-subjects factor and valence (gain vs. loss) and amount (¥1000 vs. ¥50000) as within-subjects' factors. Statistical significance was set at an alpha level of 0.05. Significant interaction effects were further decomposed using post hoc pairwise t tests.

3. Results

Table 1 shows the sample characteristics. As expected, groups differed significantly on sensation-seeking score and its subscale scores with no differences on age, gender, and educational level. HSS relative to LSS scored significantly higher on the attention-impulsivity score, the motor-impulsivity score, as well as the total impulsivity score, but not the non-planning-impulsivity score.

Table 1
Sample characteristics ($M \pm SD$).

	HSS (N = 56)	LSS (N = 57)	p value	Effect size
Gender (M/F)	28/28	29/28	.926	0.01
Age (years)	22.27 ± 1.14	22.11 ± 1.39	.497	0.13
Education (years)	15.34 ± 1.12	15.14 ± 1.23	.370	0.17
SSS-V				
Thrill and adventure seeking	8.63 ± 1.46	3.61 ± 1.86	< .001	3.02
Experience seeking	6.30 ± 1.79	2.49 ± 1.43	< .001	2.38
Disinhibition	5.79 ± 1.70	1.77 ± 1.45	< .001	2.56
Boredom susceptibility	4.04 ± 1.53	1.35 ± 1.41	< .001	1.85
Sensation seeking	24.75 ± 2.08	9.23 ± 2.85	< .001	6.26
BIS-11				
Attention	19.09 ± 2.20	17.82 ± 2.28	.003	0.57
Motor	23.00 ± 4.12	20.65 ± 3.61	.002	0.61
Non-planning	23.36 ± 4.49	22.04 ± 4.35	.115	0.30
Impulsivity	65.45 ± 9.05	60.51 ± 8.61	.004	0.56

Note. HSS, high sensation seekers; LSS, low sensation seekers; SSS-V, Sensation Seeking Scale Form V; BIS-11, Barratt Impulsiveness Scale, Version 11. All p-values, except for gender, are obtained with independent-samples t-tests with Cohen's d as effect size; the p-value for gender is associated with a chi-square test with Phi as effect size.

For the probability discounting task (Figs. 1, 2), neither group, $F(1, 111) = 0.46$, $p = .831$, $\eta p^2 < 0.01$, nor valence, $F(1, 111) = 1.59$, $p = .210$, $\eta p^2 = 0.01$, main effect was significant. However, the two-way interaction between group and valence was significant, $F(1, 111) = 6.30$, $p = .014$, $\eta p^2 = 0.05$. Follow-up pairwise comparisons revealed that HSS discounted probabilistic losses more steeply than LSS ($p = .033$), with no significant group differences observed with probabilistic gains ($p = .090$). Moreover, losses were discounted more steeply than gains in high sensation-seeking group ($p = .009$), whereas there was no valence effect in low sensation-seeking group ($p = .377$). In addition, there was a significant main effect of amount, $F(1, 111) = 27.68$, $p < .001$, $\eta p^2 = 0.20$, revealing that large amounts were discounted more steeply than small amounts. This amount effect was significant during the gain condition but not the loss condition, as reflected by a significant two-way interaction between valence and amount, $F(1, 111) = 16.00$, $p < .001$, $\eta p^2 = 0.13$.

For the delay discounting task (Figs. 1, 2), there was a marginally significant main effect of group, $F(1, 111) = 3.76$, $p = .055$, $\eta p^2 = 0.03$, indicating that HSS discounted delayed outcomes more steeply than LSS. Importantly, there was a significant three-way interaction among group, valence, and amount, $F(1, 111) = 3.99$, $p = .048$, $\eta p^2 = 0.04$. Follow-up pairwise comparisons revealed that the group effect was significant only for the large amount/loss condition ($p = .014$), but not for other conditions ($ps > .1$). Moreover, there was a significant main effect of amount, $F(1, 111) = 110.49$, $p < .001$, $\eta p^2 = 0.50$, reflecting that small amounts were discounted more steeply than large amounts. The main effect of valence was marginally significant, $F(1, 111) = 3.68$, $p = .058$, $\eta p^2 = 0.03$, which was qualified by a significant two-way interaction between valence and amount, $F(1, 111) = 5.46$, $p = .021$, $\eta p^2 = 0.05$. Post hoc pairwise comparisons revealed that losses were discounted more steeply than gains during the large amount condition ($p = .010$), but not during the small amount condition ($p = .484$).

Because of group differences on impulsivity scores on the BIS-11 (Table 1), the effects of sensation seeking on AUC values might have been modulated by impulsivity. To mitigate the potential confounding effect of impulsivity, the above ANOVA models were performed with impulsivity as an additional between-subjects factor, based on a median split of the total impulsivity score. For the probability discounting task, the two-way interaction between group and valence remained

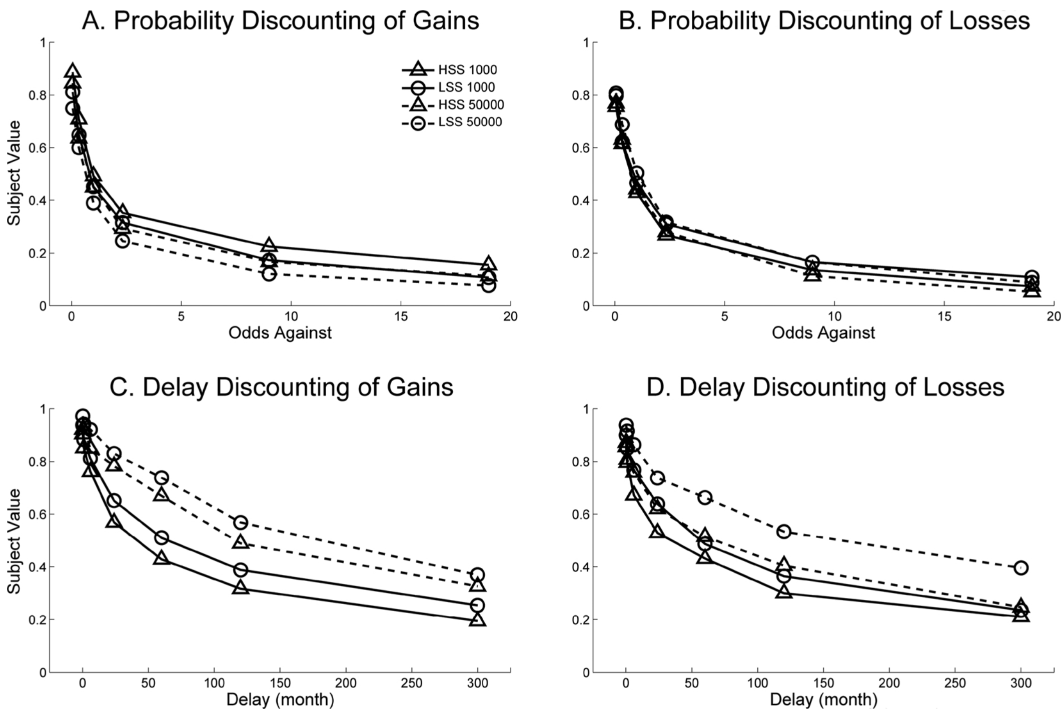

Fig. 1. Mean standardized subjective values for probabilistic gains (A), probabilistic losses (B), delayed gains (C), and delayed losses (D) in high sensation seekers (HSS) and low sensation seekers (LSS).

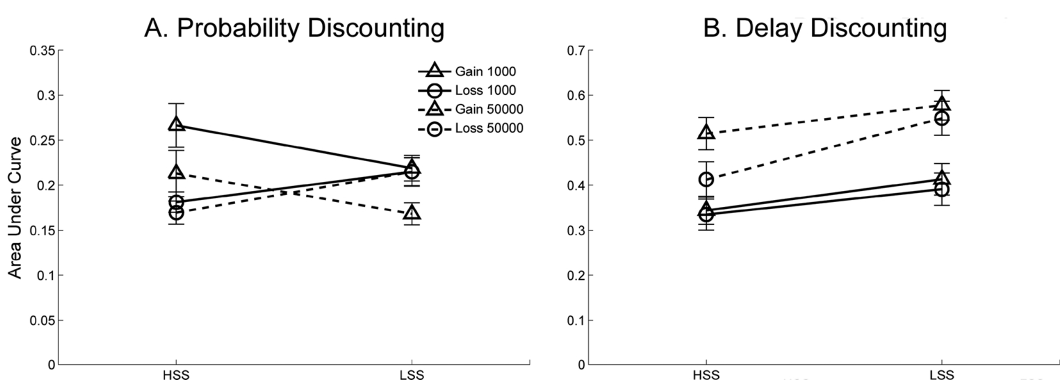

Fig. 2. The average values of area under the curve for the ¥1000 and ¥50000 gain and loss conditions in high sensation seekers (HSS) and low sensation seekers (LSS) in the probability (A) and delay (B) discounting tasks. Error bars represent standard errors of the means.

significant, $F(1, 109) = 6.84$, $p = .010$, $\eta p^2 = 0.06$. Post hoc pairwise comparisons revealed that HSS discounted probabilistic losses more steeply than LSS ($p = .021$), with no group differences observed for probabilistic gains ($p = .091$). In addition, losses were discounted more steeply than gains in high sensation-seeking group ($p = .005$), whereas there was no valence effect in low sensation-seeking group ($p = .385$). For the delay discounting task, the three-way interaction among group, amount, and valence was still significant, $F(1, 109) = 4.42$, $p = .038$, $\eta p^2 = 0.04$. Post hoc pairwise comparisons revealed that HSS relative to LSS discounted large amounts more steeply in the loss condition ($p = .021$). In addition, no significant effects involving impulsivity were found for both tasks ($ps > .1$). These results indicated that the greater tolerance to losses among individuals with high sensation seeking was preserved even after exclusion of the contribution of impulsivity.

4. Discussion

The present study systematically examined the valuation (subjective value) of gains and losses in sensation seeking during both a probability discounting task and a delay discounting task. For the probability discounting task, HSS discounted probabilistic losses but not gains more steeply than LSS, irrespective of the amount of outcome. For the delay discounting task, HSS discounted delayed losses more steeply than LSS for the large but not small amount condition. In contrast, both groups exhibited comparable performance in the rate at which gains were discounted across the two amount conditions. These results remained significant when impulsivity levels were controlled. Together, our data strengthen the argument that the dysfunctional valuation in sensation seeking may be driven by a weaker avoidance system, rather than by a stronger approach system.

For the probability discounting of monetary losses, the subjective values of probabilistic losses were discounted to a greater degree for HSS than for LSS, as indicated by a smaller AUC of probability discounting curves among individuals with high sensation seeking. Furthermore, this greater discounting of probabilistic losses was present not only for large amounts but also for small amounts, indicating that this effect is robust in sensation seeking. Our finding of the greater discounting for probabilistic losses suggests that sensation seeking is associated with higher tolerance to losses during probability decision making. This view is consistent with previous studies employing risk-taking tasks including the Balloon Analog Risk Test (Bornovalova et al., 2009; Lejuez et al., 2003a, b; Lejuez et al., 2002) and the Iowa Gambling Task (Penolazzi et al., 2013). However, participants in the previous studies were instructed to make decisions either in a gain context (gains vs. nongains) or in a combined context (gains vs. losses), which thus failed to address whether the heightened risk-taking tendency in sensation seeking is driven by a hyperactive reward system or by a hypoactive punishment system, or by both. The current study extends these studies by providing a clear demonstration of a hypoactive avoidance (punishment) system, rather than a hyperactive approach (reward) system, in sensation seeking.

Interestingly, the greater tolerance to losses was also observed in the time dimension such that HSS discounted delayed losses more steeply than LSS. One explanation for this finding is that delayed and probabilistic outcomes may be conceptually related such that discounting of delayed outcomes may reflect the risk involved during waiting for their occurrence (Fehr, 2002; Hayden and Platt, 2007; Myerson and Green, 1995). Unlike probability discounting, the blunted sensitivity to losses in the time domain was present when loss amount was large but not when it was small, indicating that individual differences in sensation seeking could be observed only when riskiness was enhanced during the delay discounting task. This possibility is in line with the optimal arousal theory of sensation seeking (Zuckerman, 1969, 1984). According to this theory, HSS versus LSS have a higher level of optimal arousal and thus need more intense sensations, larger amounts in the delay discounting task here, to reach their high level of optimal arousal.

In the present study, no significant group differences were observed for the discounting of delayed gains, which is in line with two previous studies (Ostaszewski, 1996, 1997). However, the author observed that HSS relative to LSS exhibited a lower discounting rate for larger, but not smaller, probabilistic gains (Ostaszewski, 1997). In the present study, HSS versus LSS showed a similarly reduced tendency to discount probabilistic gains, though it failed to reach significance ($p = .09$). The discrepancy might be attributable to methodological differences between the two studies. Specifically, although an adjust-amount procedure was used in both studies, our procedure is like a psychophysical staircase procedure in which the amount of the certain option on the current trial was adjusted based on participants' choice on the previous trial, whereas Ostaszwski's procedure is like the method of limits in which the amount of the certain option varied across 24 values that were predetermined. Another possibility is that the current study may not have been adequately powered to detect this finding at an alpha level of .05, which is supported by the post hoc power analysis (power = 0.70). Future research should recruit additional subjects to address this issue.

Abundant research highlights the role of dysfunctional reward processing in the development and relapse of addictive behaviors (Bickel and Marsch, 2001; Reynolds, 2006). However, together with sensation seeking as an endophenotype of drug addiction (Jupp and Dalley, 2014), the current findings imply that abnormal punishment processing may also play a critical role in addictive, more generally, risk-taking behaviors associated with sensation seeking. Actually, a plethora of evidence has shown that substance abusers do not tend to respond effectively to interventions that emphasize the role of negative consequences of substance abuse. Indeed, a core criterion of substance abuse is continued use of a drug despite negative consequences. One practical implication of the enhanced tolerance to losses in sensation seeking is that the negative consequences incurred by the engagement of substance use should be more emphasized than the positive aspects associated with the cessation of substance use among individuals with high sensation seeking.

Finally, HSS reported a higher level of impulsivity, as assessed by the BIS-11, than LSS, indicating a close relation between the two personality traits. Actually, some theorists have advocated that sensation seeking should be included under the umbrella of impulsivity (Depue and Collins, 1999; Whiteside et al., 2005). We argued, however, that it may be also important to note the differences between the two traits (Castellanos-Ryan et al., 2011; Ersche et al., 2010), given that both constitute behavioral endophenotypes of drug addiction (Jupp and Dalley, 2014). We found that the greater tolerance to losses in sensation seeking was present even after the total impulsivity score was controlled for, suggesting a partial dissociation between sensation seeking and impulsivity. This finding is consistent with the different roles of the two traits in addiction such that whereas sensation seeking is mainly associated with the initiation of drug intake, impulsivity can predict the development of drug addiction (Belin et al., 2008; Jupp and Dalley, 2014). However, it should be noted that we only assessed the single dissociation of sensation seeking from impulsivity and not the reverse dissociation of impulsivity from sensation seeking, which awaits future studies.

Several limitations are important to note. First, although using a non-clinical sample (e.g., no history of psychiatric condition or abuse) can rule out confounding factors inherent to disease states such as the neurotoxic effects, it may result in limited external validity among clinical populations high on sensation seeking. Future research should extend our findings to clinical populations such as those with substance abuse. Second, although the categorical between-group design (HSS versus LSS) utilized in this study could enlarge sensation seeking effect, it led to the neglect of more nuanced effects and interactions with sensation-seeking score. Future research using dimensional designs (i.e., examining linear relationships of sensation seeking across normal population) will be important for increasing our understanding of cognitive processes in reward- and loss-based decision making. Third, as in most other delay discounting and probability discounting tasks, the current study used hypothetical, instead of real, monetary options, which possibly decreased its external validity because it may be that participants would have reacted differently if their task performance had the potential for resulting in a tangible reward rather than a theoretical one (Hinvest and Anderson, 2010).

5. Conclusions

In the present study, we examined systematically the valuation of gains and losses in sensation seeking using a probability discounting task and a delay discounting task. Our findings demonstrated a greater tolerance to losses in HSS compared to LSS across both tasks. In contrast, the valuation of gains was comparable between HSS and LSS. These findings suggest that abnormal valuation in sensation seeking is associated with risk attitude towards loss rather than general risk attitude, supporting the view that sensation seeking is driven by a weaker avoidance system, rather than by a stronger approach system.

Conflict of interest

No conflict declared.

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Contributors

Conceived and designed the study: YZ and XL. Data collection and analysis: MT and QL. Wrote the paper: YZ and XL. All authors have approved the final article.

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