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The moderating effect of delay discounting between sensation seeking and risky driving behavior

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Abstract

It has been found that sensation seeking is a robust predictor of risky driving behavior such as violations. We considered delay discounting could moderate this relationship. Delay discounting rate represents someone's tendency to obtain immediate monetary reward or delayed larger reward. Given that risky driving behavior may associate with a trade-off between immediate sensation satisfaction and delayed safety income, it is necessary to explore sensation seeking and delay discounting's influence on risky driving at the same time. The aim of the present study is to investigate the relationship between people's delay discounting rate to hypothetic monetary reward and their self-reported risky driving behaviors, as well as explore the moderating effect of delay discounting rate on the relationship between sensation seeking and risky driving. This study used internet questionnaire to collect data. 329 Chinese drivers completed Zukerman's Sensation-Seeking Scale (SSS), The Monetary Choice Questionnaire (MCQ) and Driver Behavior Questionnaire (DBQ). The results showed that (1) discounting rate to large magnitude of delayed money (approximately $12) could negatively predict ordinary violations, errors and total risky driving behaviors; (2) discounting rate to large magnitude of delayed money (approximately $12) could moderate the relationship between sensation seeking and risky driving. Specifically, sensation seeking's influence on risky driving behavior happened only to drivers who revealed low discounting rate (tended to get immediate reward) but not to drivers who revealed high discounting rate was high (tended to get delayed but larger amount of reward). This study was the first study to discuss sensation seeking and delay discounting's influence on risky driving at the same time. The study found that only to drivers who were tended to give up larger but delayed reward and choose immediate reward, their sensation seeking score could predict risky driving frequency. However, to drivers who tended to choose delayed larger reward, they may have a better consideration of long-term safety income thus giving up chase immediate sensation satisfaction, therefore their sensation seeking score couldn't predict risky driving frequency. This study enriched the current theory frame and could be applied to select and train drivers and improve road safety.

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1. Introduction

Driving safety has always been a common concern for researchers and the public. Statistics showed that about 1.25 million people worldwide and about 100,000 people in China died due to road traffic accidents each year (WHO, 2015; CRTAS, 2013). In addition to factors related to environments and vehicles, individual characteristics are also important factors affecting traffic safety. The purpose of this study was to investigate the effects of drivers' sensation seeking tendency and delay discounting rates to monetary rewards on risky driving behaviors.

1.1. Sensation seeking and risky driving behavior

Risky driving behaviors such as aggressive driving, speeding, drink driving may cause serious driving consequences and bring great loss to drivers, pedestrians, and other road users. Previous studies have generally found that young, male, lack of driving experience drivers were more likely to conduct risk driving behavior (Harbeck et al., 2017). In addition, personality factors such as impulsiveness, sensory seeking, hostility also affect risk driving (Beirness, 1993). Among these factors, sensation seeking has been widely studied and proved to have a positive relationship with risky driving behavior in most studies (Gianfranchi et al., 2017).

Sensation seeking is a personal trait that characterized by "the seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal and financial risks for the sake of such experiences" (Zuckerman, 1994). Sensation seeking scales (SSS) was developed and widely used in researches. SSS Ⅴ includes four dimensions representing different aspect of sensation seeking: (1) Thrill and Adventure Seeking (TAS), represents the desire to participant in risky physical activities that which involves speeding or hazard experience such as skydiving; (2) Experience Seeking (ES), represents the desire to experience novel and unusual stimulus or lifestyles such as making friends with undesirable people; (3) Disinhibition (DIS), represents not limiting unruly behaviors such as binge drinking; (4) Boredom Susceptibility (BS), represents the aversion to routine, repetitive and predictable things such as watching a movie twice (Zuckerman, 1994). Drivers with higher sensation seeking level were more likely to drive while impaired and conduct other risky driving behaviors such as speeding (Jonah, 1997).

The Driver Behavior Questionnaire (DBQ) is widely used to measure individual aberrant driving behavior using self-reported frequency of aggressive violations, ordinary violations, errors and lapses (Yang et al., 2013). Behaviors in DBQ could cause bad consequences thus DBQ was used in the study to measure risk driving behavior. Recently, a study reported that sensation seeking had a positive relationship with risky driving behavior measured by DBQ (Rahemi et al., 2017).

1.2. Delay discounting

Delay discounting, or temporal discounting, refers to the phenomenon that people's perception about rewards devalues as a function of time to deliver the reward delayed (Peters & Buchel, 2011). For example, people preferred to receive $10 now over receive it a week later, sometimes people even preferred to receive $9 now over receive $10 a week later. Delay discounting rate (k) shows individual differences, in other words, some people are more bearable to wait (Mazur, 1987). Individual k value could be influenced by state thus fluctuate a little bit across time, but it is generally stable and could be seen as personal trait (Peters & Buchel, 2011). The Monetary Choice Questionnaire (MCQ) is one of the tools that could measure individual delay discounting rate (Kirby & Marakovic, 1996). MCQ includes several items and each item asks the participant to choose between a smaller immediate reward and a larger but delayed reward. Based on the response pattern among items, the range of individual delay discounting rate could be measured (Kirby et al., 1999). Higher discounting rate represents tendency to choose immediate rewards, on the contrast, lower discounting rate represents tendency to choose larger but delayed rewards.

Delay discounting has been widely studied in addiction researches. For example, studies showed that substance dependent individuals (Coffey et al., 2003), alcoholics (Petry, 2001) and pathological gamblers (Dixon et al., 2003)

had higher delay discounting rate than control groups. Individuals with higher discounting rate may prone to ignore future outcome thus tended to choose smaller immediate rewards. In driving context, studies have found that people who frequently texted while driving have higher discounting rates than those who did not frequently text (Hayashi et al., 2015). However, there was seldom research exploring the direct association between delay discounting rate and broader risky driving behaviors other than mobile phone dependence.

1.3. Sensation seeking, delay discounting and risky driving behavior

The relationship between sensation seeking and risky driving behavior could be more complex when consider other factors. A recent study found that high level of sensation seeking did not necessarily lead to risky riding behavior only when sensation seekers were also bad decision makers (Gianfranchi et al., 2017). The study proposed a new interpretation of how sensation seeking may affect risky riding behavior, that was the combined effects of sensation seeking and decision making. Similarly, we considered that delay discounting rate may modulate the relationship between sensation seeking and risky driving behavior. Whether a driver conducted risky driving behavior or not could be seen as a tradeoff between satisfying the current needs such as sensation seeking and sacrificing for more valuable future safety. Therefore, for those drivers with higher discounting rate (tended to get immediate rewards), those who at the same time tended to seeking sensory experience were more likely to conduct risky driving behaviors to feast their sensation seeking needs; however, for drivers with lower discounting rate (tended to get delayed larger rewards), even if some of them had a higher sensation seeking tendency, they may better considering longer-term safety income and giving up seeking temporary sensory experience thus do not conduct more risky driving behavior.

The aim of the present study was to, firstly, explore the association between delay discounting and risky driving behaviors. The second and main aim of the study was to examine the moderating effect of delay discounting on the relationship between sensation seeking and risky driving behaviors. It was assumed that for drivers who showed high discounting rate (tended to choose smaller immediate monetary reward), higher sensation seeking driver reported more risky driving behaviors; however, for drivers who showed low discounting rate (tended to choose larger delayed monetary reward), sensation seeking could not predict risky driving behaviors.

2. Methods

2.1. Participants

A total of 362 participants were recruited through announcement on college forum, social network and online survey platform. All participants were licensed Chinese drivers. 13 participants were excluded from the sample because of not matching recruitment condition that required the drivers must have at least one-year driving experience and drive not less than twice a week. 20 participants were excluded due to low consistency (<80%) on the Monetary Choice Questionnaire (MCQ), which in turn indicated that 94% of the participants responded to the online questionnaire carefully. In the end, 329 participants were included as valid sample (171 male, 52%). The age of the present sample ranged from 20 to 58 (M = 34.96, SD = 8.51). The annual driving kilometers of the present sample ranged from 1000 to 120000 (M = 13364.82, SD = 12845.72).

2.2. Measures

2.2.1. Driver Behavior Questionnaire (DBQ)

Driver Behavior Questionnaire (DBQ), developed by Reason et al. (1990) and adapted to Chinese by Yang et al. (2013), was chosen to measure risky driving behavior. DBQ includes 28 items and four subscales: ordinary violations (9 items), errors (8 items), aggressive violations (3 items) and lapses (8 items). Each item described an aberrant driving behavior. Participants were asked to report the frequency of these behaviors on a 5-point Likert scale from 1 (“never”) to 5 (“always”). One example item is “I know I have exceeded the legal drinking standard but still drive a car”. Higher DBQ score indicated engaging in more risky behaviors when driving. In the present study, overall DBQ score and its

subscales showed satisfied internal consistency (α = 0.73 for ordinary violations; α = 0.77 for aggressive violations; α = 0.79 for errors; α = 0.73 for lapses; and α = 0.89 for overall DBQ).

2.2.2. Zukerman's Sensation-Seeking Scale Ⅴ (SSS Ⅴ)

Zukerman's Sensation-Seeking Scale Ⅴ (SSS Ⅴ), developed by Zuckerman, Eysenck, and Eysenck (1978) and adapted to Chinese by Zhang and Chen (1990), was chosen to measure individual sensation seeking propensity. SSS includes 40 items and four subscales with 10 items each: Thrill and Adventure Seeking (TAS), Disinhibition (DIS), Boredom Susceptibility (BS) and Experience Seeking (ES). For each item, participants were asked to choose the one that matched them most from two alternative descriptions (e.g. "A. I often hope to be a mountaineer; B. I can't understand why people risk their lives to climb mountains."). Based on the choices, items were coded as 0 or 1 and then summed up to obtain overall SSS score and four subscales' score. Higher SSS score indicated having more sensation seeking tendency. In the present study, overall SSS score showed satisfied internal consistency (α = 0.86 for TAS; α = 0.53 for ES; α = 0.54 for DIS; α = 0.23 for BS; and α = 0.82 for overall SSS).

2.2.3. The Monetary Choice Questionnaire (MCQ)

The Monetary Choice Questionnaire (MCQ), developed by Kirby and Marakovic (1996) and adapted to Chinese by Liu et al. (2016), was chosen to measure delay discounting rate using hypothetical monetary rewards. MCQ includes 27 items. For each item, participants were forced to choose between a smaller immediate reward and a larger but delayed reward. One example item is "Would you prefer ¥55 today or ¥75 in 61 days?". Delayed rewards differed in monetary magnitude and all 27 items could be divided into three groups with each group 9 items: small (¥25-¥35, approximately $4), medium (¥50-¥60, approximately $8), and large (¥75-¥85, approximately $12). The delayed time ranged from one week to six months. Based on the responses pattern, delay discounting rate (k) that ranged from 0.00016 to 0.25 could be estimated for each magnitude reward group (Kirby et al., 1999; Liu et al., 2016). Values of k were then transformed to Ln(k) using a natural log transformation because k values were not normally distributed. The overall Ln(k) value was the average Ln(k) values of three magnitude groups. Higher Ln(k) values indicated greater preference for small immediate reward. MCQ has shown satisfied internal consistency and test-retest reliability (Kirby et al., 1999).

2.3. Procedure

Participants were provided an online survey link hosted by sojump. They were presented an online consent, finished DBQ, SSS, MCQ sequentially, and finally reported their demographic and driving information (e.g. age, gender, annual driving kilometers). The whole survey took about 20 minutes to complete and every participant were paid ¥20 (approximately $3). The present study was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences.

3. Results

3.1. Descriptive statistics

Descriptive statistics of each scale are shown in Table 1. Subscales of SSS were not included in the analysis on account of their low reliability coefficients (α < .60).

Table 1. Descriptive statistics for all variables.

	Number of items	Cronbach's alpha	Mean	SD
Age	-	-	34.954	8.514
Annual driving kilometers	-	-	13364.820	12845.721
TAS	10	0.857	4.009	3.083

ES	10	0.527	2.708	1.786
DIS	10	0.530	3.833	1.989
BS	10	0.230	2.641	1.463
Total SSS	40	0.820	13.191	6.158
Ln(k) small	9	-	-3.608	1.506
Ln(k) medium	9	-	-4.051	1.560
Ln(k) large	9	-	-4.542	1.545
Ln(k) mean	27	-	-4.067	1.446
Aggressive violations	3	0.768	6.593	2.424
Ordinary violations	9	0.733	16.116	4.273
Errors	8	0.792	14.067	4.015
Lapses	8	0.728	16.532	4.114
Total DBQ	28	0.893	53.307	12.115

Note: TAS = Thrill and Adventure Seeking; ES = Experience Seeking; DIS = Disinhibition; BS = Boredom Susceptibility; DBQ = Driver Behavior Questionnaire. Ln(k) small, Ln(k) medium, Ln(k) large represented discounting rate to small, medium, large magnitude of rewards respectively, Ln(k) mean = average discounting rate of three magnitude groups.

3.2. Correlation analysis

Spearman's rank correlation was used to initially estimate the association between variables. As illustrated in Table 2, delay discounting rate to large magnitude of rewards, namely Ln(*k*) large, were negatively correlated with ordinary violations (r = -0.11, $p < 0.05$), errors (r = -0.16, $p < 0.05$) and total Driver Behavior Questionnaire score (r = -0.12, $p < 0.05$).

Table 2. Correlations between variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender	-												
2. Age	-.147**	-											
3. Annual driving kilometers	-.116*	.189**	-										
4. Total SSS	-.065	-.158**	.092	-									
5. Ln(k) small	-.006	.001	.016	.028	-								
6. Ln(k) medium	.009	.054	.019	.029	.812**	-							
7. Ln(k) large	.005	.051	.042	.006	.780**	.853**	-						
8. Ln(k) mean	.006	.030	.028	.019	.919**	.949**	.930**	-					
9. Aggressive violations	-.077	-.169**	.079	.106	-.031	-.055	-.027	-.041	-				
10. Ordinary violations	-.160**	-.115*	.116*	.160**	-.075	-.065	-.112*	-.084	.572**	-			
11. Errors	.048	-.184**	.026	.127*	-.077	-.108	-.157**	-.118*	.403**	.611**	-		
12. Lapses	.106	-.203**	-.049	.065	-.031	.005	-.057	-.021	.348**	.514**	.624**	-	
13. Total DBQ	-.025	-.202**	.047	.143**	-.067	-.071	-.121*	-.086	.647**	.854**	.845**	.794**	-

Note: SSS = Sensation Seeking Scale; DBQ = Driver Behaviour Questionnaire; for gender, male = 1, female = 2; Ln(k) small, Ln(k) medium, Ln(k) large represented discounting rate to small, medium, large magnitude of rewards respectively, Ln(k) mean represented average discounting rate of three magnitude groups.
* $p < 0.05$ (two-tailed).

** $p<0.01$ (two-tailed).

3.3. The role of delay discounting in predicting risky driving behavior

A series of hierarchical regressions were conducted to examine delay discounting rates' prediction on risky driving behaviors. Based on the correlation results, ordinary violations, errors and total DBQ score were taken as dependent variables respectively. Therefore, three separated regression were conducted. In regressions predicting ordinary violations, given that age, gender and annual driving kilometers were associated with ordinary violations, they were entered in the first step as control variables. In regressions predicting errors and total DBQ score, given that age was associated with errors and total DBQ score, thus age was entered in the first step as control variables. In all three regressions, delay discounting rate to large magnitude of rewards, namely Ln(k) large, was entered in the second step. As shown in Table 3, delay discounting rate to large magnitude negatively and significantly predicted ordinary violations (β = -0.13, $p < 0.05$), errors (β = -0.14, $p < 0.05$) and total Driver Behavior Questionnaire score (β = -0.11, $p < 0.05$).

Table 3. Results of discounting rate on predicting risky driver behavior.

	Ordinary violations			Errors			Total DBQ		
	ΔR^2	β	p	ΔR^2	β	p	ΔR^2	β	p
Ln(k) large	.016	-.128	.019*	.019	-.138	.011*	.013	-.114	.036*

Note: Regressions were adjusted for age, gender, and annual driving kilometers. SSS = Sensation Seeking Scale; Ln(k) large = discounting rate to large magnitude of rewards; DBQ = Driver Behavior Questionnaire.
* $p<0.05$ (two-tailed).

3.4. Moderating effect of delay discounting

A hierarchical regression was conducted to test the moderating effect of delay discounting rates on the relationship between sensation seeking and risky driving behaviour. Total DBQ score was taken as dependent variable. Age was entered in the first step as control variable. Total sensation seeking score and delay discounting rate to large magnitude of rewards were entered in the second step, and their interaction term was entered in the third step. As illustrated in Table 4, the interaction term was significantly predicting total Driver Behaviour Questionnaire score (β = 0.11, $p < 0.05$). Specifically, as shown in Fig. 1, for drivers who had high discounting rate, high sensation seeking drivers reported more risky driving behaviours than low sensation drivers. However, for drivers who had low discounting rate, we found no significant difference in risky driving behaviours between high sensation seeking drivers and low sensation seeking drivers.

Table 4. Results of moderating effect.

Step	Variable	β	t	p	ΔR^2	Adj. R^2	F modified	p
1	Age	-.214	-3.955	.000**	.046	.043	15.646	.000**
2	Age	-.190	-3.496	.001**	.026	.063	4.571	.011*
	Ln(k) large	-.114	-2.135	.033*				
	Total SSS	.117	2.153	.032*				
3	Age	-.184	-3.412	.001**	.011	.072	4.022	.046*
	Ln(k) large	-.119	-2.228	.027*				
	Total SSS	.125	2.317	.021*				
	Total SSS * Ln(k) large	.107	2.005	.046*				

Note: Dependent variable = total Driver Behavior Questionnaire score. SSS = Sensation Seeking Scale; Ln(k) large = discounting rate to large magnitude of rewards; Total SSS * Ln(k) large = interaction term.
* $p<0.05$ (two-tailed).
** $p<0.01$ (two-tailed).

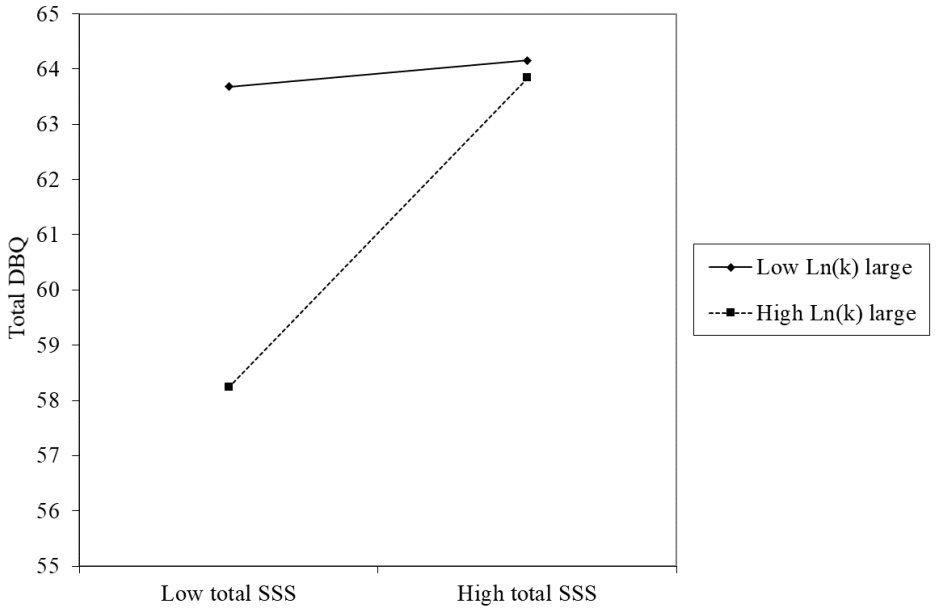

Fig. 1. Interaction between total Sensation Seeking Scale score and discounting rate to large magnitude of rewards in predicting total Driver Behavior Questionnaire score

4. Discussion

The first aim of this study was to explore the association between delay discounting rate and risky driving behavior. The second and main aim was to examine delay discounting rate's moderating effect on the relationship between sensation seeking and risky driving behavior. Online questionnaires were used to measure variables. Sensation seeking was measured by SSS, risky driving behavior was measured by DBQ and delay discounting rate was measured by MCQ. Our results showed that delay discounting rate to large magnitude of rewards (approximately $12) has a mild and negative association with risky driving behavior. And we found the relationship between sensation seeking and risky driving behavior was moderated by discounting rate to large magnitude of rewards. Specifically, for drivers who had high discounting rate, their sensation seeking tendency could predicting risky driving frequency; however, for drivers who had low discounting rate, higher sensation seeking drivers reported the same amount of risky driving behaviors as lower sensation seeking drivers.

The negative relationship between delay discounting and risky driving behavior was a surprising finding. Previous studies found addicts had higher discounting rate than control groups (Coffey et al., 2003). In driving context, a study compared delay discounting rate measured by Delay Discounting Task (DDT) among drivers who frequently texting and infrequently texting and found frequently texting group had higher discounting rate (Hayashi et al., 2015). People with higher discounting rates were seen as more impulsive and poorer at controlling themselves. However, in this study, drivers with higher discounting rates reported less risky driving behaviors. This result could be explained by some finding used another monetary reward involved paradigm named the Balloon Analog Risk Task (BART). In BART, participants were asked to inflate the balloon continuously under the risk of balloon blast (Lejuez et al., 2002). High-risk drivers found to conduct more pumps in BART (Ba et al., 2016). Some studies reported a negative association between number of pumps in BART and individual delay discounting rate (Mishra & Lalumiere, 2011, 2017). Researchers explained the negative association as those who could hardly bear uncertainty tended to pump less in BART to make sure gain and avoid loss, as well as choose instant small reward in delay discounting task to avoid the uncertainty behind delayed reward. Therefore, in the present study, the first finding that the negative prediction of the delay discounting rate on risk driving behavior could be explained by the

fact that under a large amount of delay rewards (approximately $12), those who still choose instant small rewards may be due to low tolerance of uncertainty. Thus, they may tend to avoid risky behaviors and consequences while driving.

The second and main finding was the moderating effect of delay discounting rate on the association between sensation seeking and risk driving behavior. Consistent with our hypothesis, the results revealed that for drivers who had high discounting rate, their sensation seeking tendency could predicting risky driving frequency; however, for drivers who had low discounting rate, higher sensation seeking drivers reported the same amount of risky driving behaviors as lower sensation seeking drivers. Abandoning larger rewards and choosing to get small instant rewards was seen as a manifestation of "short-sightedness for the future" (Bari & Robbins, 2013). Therefore, for drivers who tended to choose immediate rewards, if they had higher sensation seeking tendencies at the same time, it was more likely for them to ignore the hidden dangers and conduct risky driving behaviors to meet the needs of sensory experience; on the other hand, for drivers who tended to choose delayed rewards, regardless of the level of sensation seeking, they could take into account long-term safety and control the impulse to pursue sensory experience while driving, as a result there was no significant difference in their risk driving behaviors.

The present study has several limitations. One possible shortcoming is that the measurement of delay discounting rate in the study used hypothetical monetary rewards rather than real rewards. However, studies have shown that when the reward amount and delay time were similar, there was no significant difference between using hypothetical and real rewards (Johnson & Bickel, 2002). Another disadvantage is that the negative correlation between discounting rate and risky driving behavior was weak. This may be due to the majority of present sample reported low levels of risk driving behaviors. Therefore, future studies should consider recruiting more high-risk drivers. In addition, in this study risky driving behavior was measured by self-reported instrument. When response on scales, people may tend to underestimate their actual risk driving behavior and be influenced by social desirability. Future studies may consider using different tools or methods measure risk driving behaviors and consolidating the finding of this study.

Overall, firstly, the present study found that people who abandoned delayed large magnitude of rewards but still chose to get small immediate rewards reported less risky driving behaviors because of its low tolerance for future uncertainty or risk. Secondly, the study found that only for those who tended to choose immediate rewards can sensation seeking level predict risky driving behavior; for those who tended to choose delayed rewards, they may better consider the future safety then abandon seeking temporary sensory experience, thus higher sensation seeking level drivers did not reported more risky driving behaviors.

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