A Preliminary Analysis on the Subjectively-experienced Number of Trials in the Soochow Gambling Task and Risk-Taking

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Abstract

The Iowa Gambling Task (IGT) has been applied to emulate gambling-related decision making in laboratory settings. In this study, we investigated the relationship between the subjectively-experienced number of trials in the Soochow Gambling Task (SGT) and risk-taking propensity, which was measured using the Risk Propensity Questionnaire. The SGT is a modified version of the IGT, used to distinguish the expected value-based and loss frequency-based choice strategies of participants. In addition to the standard SGT, we also considered, as a trial, the negative-expected-value SGT, in which all the expected values of the decks are negative, to emulate real-life gambling situations. Our results showed that risk-taking propensity positively correlated with the accuracy of the subjectively-experienced number of trials. This tendency was slightly more evident in the negative-expected-value task. Furthermore, participants generally tended to underestimate the actual number of trials. Despite certain limitations, we suggest the possible role of subjectively-experienced number of trials in gambling tasks as a predictor of gambling-related psychological traits.

Keywords: Iowa Gambling Task, Soochow Gambling Task, experienced number of trials, risk-taking

1. Introduction

The Iowa Gambling Task (IGT) and its variations have been widely used to assess normal and impaired human decision-making process. It was developed by Bechara, Damasio, Damasio, and Anderson (1994). Many studies have used these gambling tasks to understand and extract psychological components that are involved in the development of gambling disorder and other behavioral addictions (Brevers, Bechara, Cleeremans, & Noël, 2013). In the IGT and its variations, participants repeatedly choose a card from four decks. They are not informed of the total number of trials nor which decks are advantageous. Their performance on the task has been quantified as the net score, which is calculated as the difference between the number of choices from the advantageous decks and the choices from the disadvantageous decks.

Risk-taking is a relatively stable aspect of personality that predicts the degree of gambling addiction (Powell, Hardoon, Derevensky, & Gupta, 1999). Mcbride and Derevensky (2012) reported that people who enjoy online gambling, which is a new and evolving form of gambling, tend to take more risks than those who do not gamble online. In the literature, performance on the IGT has been reported to be correlated with risk-taking propensity (Franken & Muris, 2005; Upton, Bishara, Ahn, & Stout, 2011; Xu, Korczykowski, Zhu, & Rao, 2013).

Several previous studies have investigated the subjective experience of participants in the IGT by asking them which decks they thought were advantageous. Evans, Bowman, and Turnbull (2005) found a significant correlation between the net score and subjective experience rating (e.g., "How good is deck A?") in normal controls as well as people with schizophrenia. Additionally, İyilikci and Amado (2018) observed that participants could not correctly detect the advantageous and disadvantageous decks when they experienced the emotions of fear and sadness compared to that of disgust.

In contrast, to our knowledge, subjective experience regarding how many trials the participants thought they had experienced has not been investigated; we call this the subjectively-experienced number of trials (SNT). Our hypothesis is that the SNT in repeated gambling tasks may reflect psychological characteristics that are relevant in predicting risk-taking propensity. Garavan (1998) showed that when it was easy for participants to focus attention on a cognitive task, they could respond more quickly than otherwise. Thus, it might be reasonable to assume that the amount of attention directed toward gambling tasks and SNT are related. Because people who are inclined to gamble narrow their attentional focus and concentrate on the current gamble (Diskin & Hodgins, 1999) or exhibit present-centered time orientation (MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006), they may also be better at judging the number of trials experienced. Because SNT data are very easy to collect, we suggest that these properties are worth studying. Therefore, the current study is a preliminary investigation of the characteristics of SNT in the repeated gambling task, including their relationship with risk-taking propensity.

In the IGT literature, there has been debate as to whether participants choose the decks based on the expected value (EV) or loss frequency. This debate was prompted by the existence of a critical confounding of the two in the gain-loss structure of the IGT (Lin, Chiu, Lee, & Hsieh, 2007).

Specifically, in the IGT, advantageous decks have a considerably lower frequency of net losses than do disadvantageous decks (see Tables 1 and 2 of Chiu et al., 2008). To resolve this problem, Chiu et al. (2008) developed the Soochow Gambling Task (SGT) by modifying the gain-loss structure of the IGT. The SGT is designed to distinguish EV-based and loss frequency-based choice behavior of participants.

However, when these extant gambling tasks are used to study real-life gambling-related behavior, there still exists a noticeable discrepancy: the EVs of advantageous decks are positive in the SGT as well as the IGT, but in almost all real gambling — such as horse racing, casino games, and lotteries — EVs are actually negative. Therefore, in this study, we also developed and considered, on a trial basis, a modified version of the SGT, in which EVs of all choice options are negative. We call this modified version the negative-expected-value SGT (NEV-SGT).

To assess risk-taking, we used the Risk Propensity Questionnaire (RPQ; Moriizumi & Usui, 2011; Moriizumi, Usui, & Nakai, 2010) in this study. Moriizumi and Usui (2011) established the reliability and validity of this questionnaire for Japanese people in various age and occupational groups. They reported a significant correlation between the RPQ and another measure or risk-taking, namely the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). The RPQ consists of four subscales: gambling behaviors, occasional risk-taking, risk-taking with individual values, and risk-avoiding. The questionnaire enables the measurement of multiple aspects of risk-taking propensity.

Using the aforementioned measures, the objective of the current study was to undertake a preliminary investigation of the properties of SNT in the SGT and NEV-SGT in terms of its relation to risk-taking propensity. If SNT predicts risk-taking, it could be a valuable indicator of gambling-related psychological traits or behavior, which may represent new knowledge. We also investigated whether systematic biases exist in the SNT, to better understand its properties.

2. Method

2.1 Participants

Thirty Japanese university students (22 males and 8 females) participated in the experiment (mean age: 21.4, range: 20-23). All participants gave written informed consent to participate in the study. They were informed of having the right to quit the experiment and to withdraw their consent form. To motivate the participants to fully engage in the task, they were told that they would receive a larger participation fee when their scores were above a certain level. The participants were debriefed regarding this misdirection at the end of the study. After the experiment, all participants received a book coupon worth 500 yen as their participation fee.

2.2 Apparatus

The SGT and NEV-SGT were implemented in OpenSesame 3 on a Windows computer. The gain and loss structures of the SGT and NEV-SGT are presented in Table 1. To maintain ecological validity for the participants, we used Japanese yen as the actual unit of currency in the tasks. The values are presented in dollars in this paper, at an exchange rate of $1 = 100 yen. As shown in the Table 1, the difference in EVs between the advantageous and disadvantageous decks was $1000. In the two tasks, participants were presented with the four decks, and were asked to choose one of them by pressing the "1" key on a keyboard to choose deck A, "2" key to choose deck B, and so on. In both tasks, participants initially had $2,000. After each trial, the losses and rewards (if any) were presented separately to participants at the center of the screen. In every trial, $50 was extracted from the total amount (i.e., bet)[1]. The current and previous total amount were always displayed at the top of the screen.

The RPQ (Moriizumi & Usui, 2011; Moriizumi, Usui, & Nakai, 2010) consists of 17 five-point Likert-scale items: five items for gambling behaviors, six items for occasional risk-taking, three items for risk-taking with individual values, and three items for risk-avoiding.

2.3 Procedure

The experiment was conducted using a within-participant design. Half of the participants performed the SGT first and then the NEV-SGT, while the others performed the NEV-SGT first and

Table 1

Gain and Loss Structures of the SGT and NEV-SGT

	SGT				NEV-SGT			
Initial Money	2000				2000			
Loss per Trial	50				50			
Gain per Trial	Deck				Deck			
	A	B	C	D	A	B	C	D
1	250	150	-150	-50	250	150	-150	-50
2	250	150	-150	-50	250	150	-150	-50
3	250	150	-150	-50	250	150	-150	-50
4	250	150	-150	-50	250	150	-150	-50
5	-1000	-600	1100	700	-1300	-900	800	400
6	250	150	-150	-50	250	150	-150	-50
7	250	150	-150	-50	250	150	-150	-50
8	250	150	-150	-50	250	150	-150	-50
9	250	150	-150	-50	250	150	-150	-50
10	-1000	-600	1100	700	-1300	-900	800	400
Net Outcome	-500	-500	500	500	-1100	-1100	-100	-100
Summary	disadvantageous		advantageous		disadvantageous		advantageous	

Note. Currency = $.

[1] For example, in the NEV-SGT, if participants continued to choose deck A ten times, they received $-1100; (-50) × 10 [bet] + 250 × 8 [gain] + (-1300) × 2 [loss] = -1100 [net outcome].

then the SGT. Procedures and instructions given to the participants were the same for the two tasks. Following İyilikci and Amado (2018), participants were randomly assigned to either the ABCD task, in which the order of presentation of the four decks on the computer screen was A, B, C and D, or the DCBA task, in which the order was reversed. Participants were told to earn as much money as possible. Instructions were employed from Bechara, Damasio, Damasio, and Lee (1999). Consistent with most extant studies (e.g., Cassotti, Houdé, & Moutier, 2011; Wright, Rakow, & Russo, 2017), 100 trials were performed but participants were not informed of the number of trials in advance. They were told to continue the task until it was complete. The task continued even if the participants' total amount of money became negative. At the end of each task, the participants were asked how many times they thought they had chosen each deck in paper format; the sum of these values was defined as the SNT value for the task.

After the two tasks were complete, participants answered the RPQ, stated whether they had participated in similar gambling task experiments previously, and provided their demographics (nationality, gender, and age) in paper format. The whole participation process took approximately 30 minutes per participant. The experimental protocol was reviewed and approved by the institutional ethics committee of The University of Tokyo.

2.4 Data Analysis

Data analysis was conducted using R (ver.3.6.2). To measure the accuracy of participants' subjective perception of the number of trials performed, we calculated δ as the absolute difference between the reported SNT and 100. The closer to zero δ was, the more accurate the perception of the actual number of trials performed. For the RPQ, the mean scores for each subscale as well as the grand mean were calculated. Following Bechara et al. (1994), the recorded choices of the 100 trials were sub-divided into five blocks of 20 trials each. The block-total scores in both the SGT and NEV-SGT were calculated by subtracting the number of choices from disadvantageous decks from the number of choices from advantageous decks in each block: (C + D) − (A + B), where A denotes the number of choices from deck A in that block (the same applies to B, C, and D). Consistent with previous studies (e.g., Buelow, Okdie, & Blaine, 2013; Huizenga, Crone, & Jansen, 2007), the net score was then calculated as the mean of the final three block-total scores (blocks 3–5), to take learning effects into consideration. The correlations between (1) δ and RPQ scores and (2) net score and RPQ scores were then calculated.

3. Results

3.1 Participants

No participants withdrew from the study. Two participants chose the same deck more than 90 times in one or both of the tasks. We considered this as irregular, and decided to use the data from the other 28 participants. Three of them reported previous experience participating in similar gambling task experiments. However, based on the observed data, we did not find substantial evidence that there was an effect of prior experience, as follows. The means of δ in the SGT were 20.0 (*SD* = 20.0) in the prior experience group and 30.5 (*SD* = 20.0) in the other participants (Welch's t-test: $t(2.51) = 0.86$, $p = .46$). The means of δ in the NEV-SGT were 28.3 (*SD* = 24.7) in the prior experience group and 30.4 (*SD* = 22.5) in the other participants ($t(2.42) = 0.14$, $p = .90$). Furthermore, the mean net scores in the SGT were 4.67 (*SD* = 8.08) in the prior experience group and -3.49 (*SD* = 11.3) in the other participants ($t(3.04) = 1.57$, $p = .21$). The mean net scores in the NEV-SGT were 0.22 (*SD* = 12.5) in the prior experience group and -0.64 (*SD* = 9.43) in the other participants ($t(2.28) = 0.12$, $p = .92$). Thus, we decided to use the data of all 28 participants in the following analysis.

3.2 Apparatus

We did not find evidence for a group difference between the two presented orders of the task. Specifically, the mean net scores in the SGT were -0.58 (*SD* = 10.9) in the ABCD task group and -4.97 (*SD* = 11.5) in the DCBA task group ($t(25.0) = 1.03$, $p = .31$). The mean net scores in the NEV-SGT were 0.05 (*SD* = 11.2) in the ABCD task group and -1.14 (*SD* = 7.84) in the DCBA task group ($t(23.2) = 0.33$, $p = .75$). Therefore, in the following analyses, we pooled the data from both task groups. There was a relatively large correlation between δ in the SGT and NEV-SGT ($r = .72$, $p < .01$, 95% CI [.48, .86]) and between the net scores of the SGT and NEV-SGT ($r = .57$, $p < .01$, 95% CI [.25, .78]). These results suggest that the NEV-SGT could measure constructs similar to the SGT. The grand mean of the RPQ scale was 2.41 (*SD* = 0.53), and mean scores of the subscales were 2.51 (*SD* = 0.84) for gambling behaviors, 2.86 (*SD* = 0.77) for occasional risk-taking, 1.77 (*SD* = 0.67) for risk-taking with individual values, and 1.96 (*SD* = 0.82) for risk-avoiding. No signs of ceiling or floor effects were observed among these scores. Mean δ was 29.4 (*SD* = 19.9) in the SGT and 30.2 (*SD* = 22.3) in the NEV-SGT.

3.3 Underestimation of SNT and Correlation Between δ and RPQ

Mean SNT was 71.7 in the SGT and 74.5 in the NEV-SGT. These values were significantly smaller than the actual number of trials (i.e., 100; SGT: $t(27) = 31.7$, $p < .01$, NEV-SGT: $t(27) = 24.0$, $p < .01$). That is, in general, the SNT was an underestimate. The correlation coefficients between δ and RPQ subscales are presented in Table 2. In the SGT, moderate-to-large negative correlations were found between δ and risk-taking with individual values ($r = -.45$, $p = .02$) and risk-avoiding ($r = -.37$, $p = .06$). In the NEV-SGT, moderate negative correlations were found between δ and gambling behaviors ($r = -.38$, $p = .05$), risk-avoiding ($r = -.40$, $p = .03$), and the grand-mean RPQ score ($r = -.36$, $p = .06$). The relationship between δ and the grand-mean RPQ score in the NEV-SGT is presented in Figure 1. Participants whose δ was smaller tended to have a higher RPQ score.

3.4 Correlation Between Net Score and RPQ

Correlations between the net scores and the grand-mean RPQ score were small (SGT; $r = .04$,

Table 2

Correlation coefficients between δ and RPQ

	GB	OR	RIV	RA	Grand mean
SGT	-.24	.04	-.45*	-.37†	-.30
NEV-SGT	-.38*	-.03	-.26	-.40*	-.36†

Note. GB = gambling behaviors; OR = occasional risk-taking; RIV = risk-taking with individual values; RA = risk-avoiding. * $p < .05$, †$p < .10$.

NEV-SGT; $r = -.15$). Correlations between the net scores and RPQ subscale scores were also generally small ($|r|$'s < .19), except for risk-taking with individual values in the SGT ($r = .35$, $p = .07$). No significant correlations were found between these two measures.

4. Discussion

We undertook a preliminary investigation of the relationship between SNT in the NEV-SGT as well as in the SGT and risk-taking propensity. Our results indicated that the participants whose SNT was more accurate tended to have higher risk-taking propensity, and this tendency was slightly more pronounced in the NEV-SGT. In contrast, the net scores on the gambling tasks generally did not correlate with risk-taking propensity. Additionally, respondents' SNT were generally smaller than actual number of trials they performed. We discuss the implications of these findings below.

Negative correlation coefficients between -.30 and -.50 were found between δ and three subscales of the RPQ as well as its grand mean. This result might be evidence that SNT reflects psychological characteristics relevant in predicting risk-taking propensity. As we discussed in the Introduction, a probable explanation for this involves attention (e.g., Diskin & Hodgins, 1999; MacKillop et al., 2006). That is, gambling-inclined people tend to pay more attention to the gambling task, which could lead to higher accuracy of guessing the number of trials afterwards. A similar explanation replaces attention with arousal. When playing gambling tasks, it has been reported that people who are inclined to gamble tend to have higher arousal than normal controls (Leary & Dickerson, 1985). The degree of gambling addiction and tendency toward risk-taking are also correlated (Powell et al., 1999). Thus, participants with high risk-taking propensity might tend to have higher arousal in gambling tasks, and thereby make systematic and more accurate guesses of the number of trials.

These correlations were slightly more pronounced in the NEV-SGT than in the SGT. Thus, the SNT in negative-expected-value gambles, which is a property that most real gambling shares, might be more suitable than the conventional SNT for predicting risk-taking propensity. To the authors' knowledge, gambling tasks in which all choice options have negative EVs have not been investigated in previous studies. This study indicates that it would be worthwhile to explore the utility of negative EVs in gambling tasks. Another experiment would be required to investigate how pathological gamblers perform on the gambling tasks with negative EVs, such as NEV-SGT. Some effective knowledge for clinical contexts may be obtained from such an experiment.

In contrast, correlation coefficients between the net score of SGT tasks and RPQ subscale scores, as well as its grand-mean score, were generally close to zero. This result may appear to contradict previous studies that used the IGT (e.g., Upton et al., 2011; Xu et al., 2013). This apparent discrepancy might be a result of the difference in the meaning of the net score between the IGT and SGT. That is, the net score on the SGT becomes larger when participants make choices based on EV and becomes smaller when they choose based on loss frequency, whereas the net score on the IGT should become larger when the participants choose the decks based both on EV and loss frequency (Chiu et al., 2008). In this sense, our result that in the SGT and NEV-SGT SNT has better predictive power for risk-taking propensity than does net scores does not contradict previous IGT results. Because the IGT has a confounding problem in its gain-loss structure, it would be worthwhile for a future study to investigate comparative performance on SNT in the SGT.

Furthermore, SNT was generally underestimated by the participants. This result is consistent with Noseworthy and Finlay (2009), whose participants tended to report their subjective time playing slot machine gambling as shorter than the actual time spent, and with Haj, Moroni, Samson, Fasotti, and Allain (2013), whose participants underestimated the retrospective time engaged in various cognitive activities, such as judging whether target words were abstract or concrete. The results of these studies can be interpreted as showing that the strength of cognitively-processed stimuli affects time perception. In laboratory cognitive tasks, Poynter and Homa (1983) reported that the number of changes in a

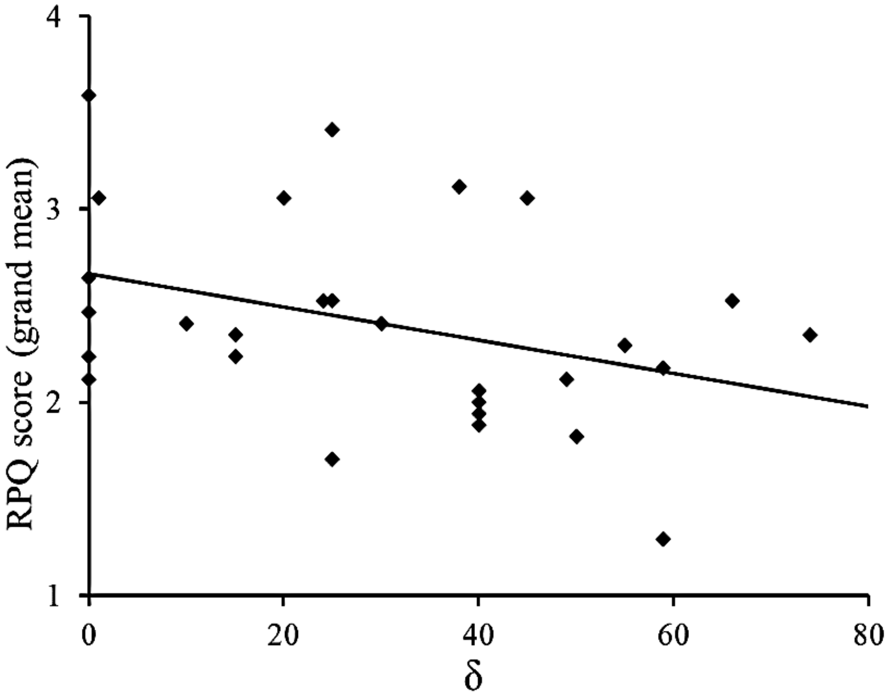

Figure 1. Relationship between δ and the grand-mean RPQ score in the NEV-SGT. The line is the regression line.

stimulus pattern is positively correlated with time perception. Additionally, Poynter (1989) reported that when there are few sensory events, the interval between events is perceived as shorter than the actual time. In our gambling tasks, the graphics did not differ greatly among trials. Participants saw similar screen patterns many times, and there were few notably distinct events in the tasks. Accordingly, underestimation of SNT could be explained by the same mechanism as for underestimation of time. However, in our experiment, we did not ask participants about the time spent on the task. The relation between the SNT and perceived time should be investigated further.

Although the results of the current study provide new insights and perspectives regarding the subjective experiences of participants in gambling tasks, the study was also subject to some limitations. First, we did not measure participants' attentiveness, arousal, or time perception, which could be potential mediators during the task. This prevents us from considering as final the working hypothesis that explains the relationship between the SNT and risk propensity, and underestimation of SNT; other more complete explanations might exist. Second, the sample size in this study was relatively small. The robustness of the current results should be confirmed in future research. Additionally, the gender ratio of the current participants was unbalanced, and hence, it was difficult to investigate the effect of gender. The relation between gender and SNT should be investigated more. Third, when participants were asked to report how many times they thought they had chosen each deck, they might have assumed that the actual number of trials was a round number. Indeed, four participants' δ was 0 in both tasks. Nevertheless, when we removed the data of these four participants from the analysis, the resulting tendencies was essentially the same as when considering the entire dataset. For example, the correlation coefficient between δ and the grand-mean RPQ score in the NEV-SGT was -.38 (p = .07). Therefore, this problem does not appear serious, although it bears consideration nevertheless.

This study was conducted as a preliminary investigation; hence, the relationship between SNT and risk-taking behavior needs to be further investigated in future research. Owing to the above-mentioned limitations, we are not yet convinced that the current results are robust. However, it is possible that SNT could be measured in many kinds of gambling-unrelated tasks. Comparison of the ability of SNT to predict performance in such cases would be an interesting direction for future studies. The accumulation of basic knowledge, such as in the current study, may help foster understand of the mechanisms and motives underlying gambling addiction.

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