EFFECT OF EMOTIONAL DISTRACTERS ON COGNITIVE DECISION-MAKING IN CAMBRIDGE GAMBLING TASK

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Human decision-making has been investigated under two frameworks: cognitive and emotional decision-making. Cognitive decision-making is a choice behavior in the risky situation, in which the payoff and the probability of each option are explicit and calculable. This form of decision-making has been considered to be performed without emotional influence. Although recent works have revealed the importance of the emotion in human decision-making, emotional effect on cognitive decision-making is yet unknown. To examine whether cognitive decision-making is affected by emotional distracters, we implemented a secondary task requiring short-term memory of an emotional word in the Cambridge gambling task (CGT). Although the quality and the quickness of decision-making were not affected by emotional distracters, the amount of bet was significantly higher in trials requiring positive word memorization. These results indicate that some processes of cognitive decision-making are affected by emotion.

Key words: decision-making, emotion, anxiety, Cambridge gambling task, Iowa gambling task

Decision-making is one of the most important functions of human behavior. Our everyday lives are composed of repetitive decisions to select an optimum option from many possible alternatives of action. The nature of human decision-making has been investigated in two frameworks: cognitive and emotional decision-making (Brand, Labudda, & Markowitsch, 2006). Emotional decision-making is a choice behavior under ambiguous situations in which the information regarding the payoff and the probability of each option is insufficient. Iowa gambling task (IGT) developed by Damasio’s group (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, & Damasio, 2005) is one of the typical behavioral tasks which requires emotional decision-making. In the IGT, the subject needs to accomplish 100 card selections from four options of card decks. Every card selection provides gain of the game money, but sometimes provides loss simultaneously. Four decks have different schedules of gains and losses, but the subject is not informed about these schedules and must learn the optimum choice strategy in a trial-and-error manner. Based on the series of experiments using the IGT, Damasio (1996) proposed somatic marker hypothesis, an important theory explaining the roles of the emotion in decision-making. Somatic marker hypothesis assumes that the decision is biased by the autonomic somatic responses closely linked to the emotion (Bechara et al., 2005; Damasio, 1996).
Cognitive decision-making, on the other hand, is a choice behavior under risky situations in which the payoff and its probability of every option are explicit and calculable. Classic economics have long been interested in rational choice strategies in a variety of risky situations. These studies assumed that humans made economically advantageous decisions by estimating the expected values and reward probabilities. However, emotional effect on decision-making is recently paid more attention (Bechara, Damasio, & Damasio, 2000; Dolan, 2002; Pessoa, 2008). Therefore, whether or not cognitive decision-making is affected by emotion is an important issue. Cambridge gambling task (CGT) has been known as a typical task requiring cognitive decision-making (Clark et al., 2008; Manes et al., 2002; Rogers, Everitt et al., 1999). In this task, the subjects accomplish a relatively simple probabilistic decision in order to get a token hidden in one of the ten boxes. Each box is colored in either pink or blue. In every trial, the subjects select the color of the boxes which they think the token is hidden inside. Also the subjects choose how much to bet on the color choice from the current balance of the game money. Since the payoff and its probability for each color choice are explicitly known to the subjects, they have to make an optimum decision based on a comparison of the payoffs and their probabilities among the options in order to earn as much game money as possible. However, the emotional effect on the performance of the CGT is not well understood. In the present study, we used a modified CGT which was combined with short-term memory of emotional Japanese words (emotional distracters) and examined whether or not choice behavior necessary to the CGT performance was affected by emotional distracters. In this CGT, subjects were required to remember either emotional or non-emotional word at the beginning of each trial and recall it at the end of the trial. Similar paradigms had been used in the IGT by Hinson, Jameson, & Whitney (2006).

METHODS

Subjects
Twenty-eight university students (14 female; 14 male; average 21.4 year-old) participated in this study.

Equipments
A laptop computer (SR6KX06, KOHJINSHA, Yokohama, Japan) and a 17-inch LCD display (VL-17TX, Fujitsu, Tokyo, Japan) were used for this study. All the stimuli and instructions were presented on the display. Task programs were constructed using Matlab (MathWorks, Natick, MA, USA) and Psychophysics Toolbox 2 (Brainard, 1997). Number keys were used for the subject to make responses during the task. To ensure the subject’s accuracy of word recall in the modified CGT, the subject’s answer was recorded by an IC recorder.

Behavioral Tasks

A Modified Version of Cambridge Gambling Task (CGT)
We used a modified version of the CGT in the present study, although the basic rules and the appearance of stimuli were the same as the original CGT by Rogers, Everitt et al. (1999). In each trial, an array of 6 pink and blue boxes was presented at the top of the display (Fig. 1A), and the subject needed to make a decision which colored box had a yellow token. The box in which the token was hidden was randomly selected by the computer. The ratio of the numbers of pink and blue boxes varied from 1:5 to 5:1,
although pink boxes were always placed on the left-hand side. The subject’s choice of a colored box was made by pressing a number key. When the subjects wanted to select pink, they pressed the ‘4’ key by the right index finger. When the subjects wanted to select blue, they pressed the ‘6’ key by the right ring finger. After choosing one of the two colors, the subjects needed to make a decision how much game money to bet on their choice. Available options that the subjects could bet were 5, 25, 50, 75, or 95% of the money that the subjects currently had. Each bet option was displayed for 1 sec on the right-hand side of the display in either ascending or descending order. The subjects had to choose one bet option by pressing the ‘5’ key by the right middle finger. The game money that the subjects currently obtained was always shown on the left-hand side of the display. After the subjects selected one color and one bet option, the box in which the token was
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hidden was shown by displaying a yellow X on the box. If the chosen color was the same as that of the box in which the token was hidden, earned money was displayed in green below the display of the current money, and it would be added to the subjects' current amount of money. If the chosen color was different from that of the box where the token was hidden, the money bet was displayed in red, and it would be subtracted from the current amount of money. The goal of this task is to earn as much game money as possible.

Subjects could perform up to 50 trials in one session, which was divided into 5 blocks of 10 trials. Subjects were not informed about how many trials they had to perform. At the beginning of each block, subject's current amount of money was reset to 10,000 yen to avoid for the subject to change the betting strategy depending on the subject's current amount of money. If the amount of money dropped below 1 yen, no more trial could be made in that trial block because of the bankruptcy. In this case, the current trial block was immediately terminated, the subject's money was reset to 10,000 yen, and the next trial block was started.

In our modified version of the CGT, short-term memory of a Japanese word was required. At the beginning of each trial, a single Japanese word composed of two Chinese characters was presented for 2 sec (Fig. 1B). The subjects were asked to retain it during the performance of the CGT trial and recall it at the end of the trial. The word presented on the display varied from trial to trial, and the order of word presentation was pseudo-randomized. Three different groups of Japanese words (positive, neutral, and negative emotional words) were used. The classification of words was based on Gotoh and Ohta (2001). We selected 40 positive words (affective score, 2.5 or less), 40 negative words (affective score, 5.5 or more), and 20 neutral words (affective score, around 4.0) from their list of words. Then we constructed two emotional loading sessions. Positive load session was composed of 30 positive words, 10 negative words, and 10 neutral words. Negative load session was composed of 30 negative words, 10 positive words, and 10 neutral words. The mean affective score was 3.17 ± 1.76 (SD) for positive load session and 4.83 ± 1.77 (SD) for negative load session.

Subjects were first explained about basic rules of the CGT, and performed 6 CGT trials without short-term word memory task. After this procedure, they were explained about the word memory task and performed 2 more CGT trials with short-term word memory task for practice. Subjects were explicitly explained that the word presented at the beginning of the CGT trial had no relation to the CGT itself. Each subject performed two sessions of the CGT (positive and negative load sessions) at their own pace. The order of the emotional load sessions was counterbalanced across subjects. A short break (about 5 min) was introduced between sessions.

Iowa Gambling Task (IGT)

We used a computerized version of the IGT in which emotional decision-making is an important component (Bechara et al., 1994; Bechara, Tranel, & Damasio, 2000). In this task, 4 decks of face-downed cards were presented on the display. Subjects needed to select one card at a time (one trial) from one of the 4 decks. Each card informed subjects how much game money they earned and how much money they lost. The goal of the IGT is to earn as much game money as possible. If subjects picked up a card from two (deck A and B) of these 4 decks, they would obtain a large amount of money (i.e. 10,000 yen) on every choice, but would lose a larger amount of money (e.g. 30,000 yen) by occasional punishment. Therefore, continuous selection of the card from the deck A or B would lead to lose the money. On the other hand, if subjects picked up a card from other two decks (deck C and D), they would obtain a small amount of money (i.e. 5,000 yen), but would lose a smaller amount of money (e.g. 2,500 yen) by punishment. Therefore, continuous selection of the card from the deck C or D would lead to gaining money. To select a card from the deck, subjects needed to press one of the number keys, each of which corresponded to one of the decks. Subjects were given 200,000 yen at the beginning of the task and needed to earn as much game money as possible through 100 trials. Since it is not known how much money subjects obtain at each choice of the card, how often subjects receive the punishment, and which card deck is advantageous, they have to find the optimum choice strategy by themselves.

State-Trait Anxiety Inventory (STAI)

In the present study, the state-trait anxiety inventory (STAI) was used to estimate subject's level of anxiety. Anxiety is one of the important factors to consider human emotion. Subject's anxiety can be classified into two relatively independent components: state anxiety and trait anxiety (Spielberger, Gorsuch, & Lushene, 1970). State anxiety (SA) is thought to be an index of subject’s momentary anxious states,
whereas trait anxiety (TA) can be used as an index of subject’s general trend to become anxious. Different performance of the IGT has been observed between high and low TA groups (Miu, Heilman, & Houser, 2008), suggesting that decision-making is affected by anxiety levels. We used the STAI in order to understand the subject’s emotional characteristics. In the present study, we translated the original version of the STAI proposed by Spielberger et al. (1970) into qualitatively similar 40 Japanese questions with reference to the Japanese version of the STAI (Nakazato & Mizuguchi, 1982). We examined whether or not the subject’s scores of these two anxiety indices have any relation to the performance of the decision-making tasks.

**Experimental Procedure**

All subjects first performed the IGT and then two CGT sessions. After performing the IGT and the CGT, subjects answered 40 questions of the STAI. The IGT was always introduced first to avoid possible interference with the IGT performance by emotional words used in the CGT. Whole experiment took about 45 min to 1 hour for each subject.

**Statistical Analysis**

Obtained data were analyzed statistically using R (version 2.7.2), a free open-source statistical analysis system (www.r-project.org/). We applied arcsine-transformation to the proportion of each subject’s safe choice in the CGT, which is a common method to reduce the skewness of the proportional data. Most subjects hardly selected the color option which had higher risk of punishment in the CGT (the color of fewer boxes, 1.4 ± 3.3 trials/session). Therefore, for the analysis of reaction times and the amount of bet, we only used data obtained from the trials in which the subject selected safer color (the color of equal or more boxes, 48.2 ± 4.3 trials/session). By this application, we could analyze the subject’s RT and amount of bet independently from the quality of the color decision. Paired t-test and repeated measures ANOVA were used to compare subject’s performances between two CGT sessions and performances among blocks in the IGT. We used the Mendoza’s test to verify the sphericity of the data, and the Greenhouse-Gaisser correction was applied when the sphericity was violated. As the post-hoc analysis of ANOVA, the Shaffer’s modified sequentially rejective multiple test was used.

**RESULTS**

All 28 subjects completed the IGT, two CGT sessions, and the STAI. The data obtained from one subject were excluded from the analysis, because the accuracy of short-term word memory task in the CGT did not reach the criterion of 90% correct performance.

**Result of State-Trait Anxiety Inventory (STAI)**

In the present study, we used the STAI to characterize the subject’s momentary and general levels of anxiety, which are important components to understand the subject’s emotional property. The STAI includes 20 questions for testing state anxiety (SA) and other 20 questions for testing trait anxiety (TA), and separately offers indices of these two types of anxiety (Spielberger et al., 1970). High score of the SA indicates that the subject has high level of anxiety momentarily, while high score of the TA indicates that the subject has greater tendency to get anxious. We calculated both scores for each subject. The average score of the subjects was 45.5 ± 6.4 (SD) for SA and 51.8 ± 10.5 (SD) for TA. These scores were similar to those observed in Japanese university students (Nakazato & Mizuguchi, 1982; Shimizu & Imae, 1981), indicating that subjects in the present study represent ordinary Japanese university students.
Results of Cambridge gambling task (CGT)

Color Selection

An analysis regarding which color the subjects frequently selected in the CGT revealed that the subjects highly preferred to select the color of the boxes that appeared in a larger number. As is seen in Fig. 2, when the number of pink boxes was larger than the number of blue boxes, the subject tended to select pink. This result indicates that the subjects seem to perform safer choice, because the subjects have a higher probability to get the token if they select the color of the boxes that appeared in a larger number. We then examined whether or not the subjects’ safer choice was affected by the difference of emotional load sessions (positive vs. negative). However, as is seen in Fig. 2, the subjects’ selection of color was not affected by the difference of emotional load sessions (ANOVA, $F_{1,26} = 0.03, p = 0.87$).

Fig. 2. Color selection in the CGT. This graph indicates proportion of subject’s selection of the pink box. Color ratio indicates the ratio of pink vs. blue boxes (pink:blue). For example, 1:5 means that top 6 boxes consist of one pink box and 5 blue boxes. Gray solid and dotted lines indicate the results obtained under the positive or the negative emotional load sessions for each subject, respectively. Black solid and dotted lines indicate between-subject averages under two emotional load sessions. For a presentation purpose, small jittering was applied to the plot. Error bars: s.e.m.
Reaction Time

We analyzed reaction times (RTs) at the color selection to examine whether the quickness of the decision-making were affected by the likelihood of the outcome. The RT was defined as the duration between the time at the appearance of colored boxes on the display and the time when the subject pressed a number key to choose either pink or blue. As is seen in Fig. 3, subjects showed longer RTs (1.35 ± 0.50 s) when the same number of pink and blue boxes appeared ([3:3] condition), shorter RTs (1.03 ± 0.29 s) when the ratio of pink boxes vs. blue boxes was 2:4 or 4:2 ([4:2] condition), and the shortest RTs (0.98 ± 0.30 s) when the ratio was 1:5 or 5:1 ([5:1] condition). RTs in these three conditions were significantly different (ANOVA, $F_{2,52} = 31.75$, G-G corrected $p < 0.001$; Shaffer’s method, $p < 0.05$). These results indicate that RTs were affected by the ratios of pink and blue boxes and that the subject made faster decision in the safer choice condition (i.e. [5:1] condition) than in the riskier choice condition (i.e. [3:3] condition). We also examined whether the difference of emotional load sessions (positive vs. negative) affected RTs or not. However, as is seen in Fig. 3, there was no significant difference in RTs between two emotional load sessions across different ratios of pink and blue boxes (ANOVA, $F_{1,26} = 0.19$, $p = 0.67$).

Fig. 3. Reaction times for color selection. Color ratio indicates the ratio of pink vs. blue boxes (pink:blue). Gray solid and dotted lines indicate the results obtained under the positive or the negative emotional load sessions for each subject, respectively. Black solid and dotted lines indicate between-subject averages under two emotional load sessions. Error bars: s.e.m.
Choice of Bet Option

We analyzed the amount of bet in the CGT to analyze the subject’s risk adjustment. As is seen in Fig. 4, the subject’s choice of bet option was significantly affected by the ratio of the colored boxes (ANOVA, $F_{2,52} = 72.18, p < 0.001$). The subject tended to select larger bet option in the [5:1] condition ($68.7 \pm 20.0\%$) and smaller bet option in the [3:3] condition ($28.2 \pm 20.1\%$). These differences were statistically significant (Shaffer’s method, $p < 0.001$). We also examined whether the difference of emotional load sessions (positive vs. negative) affected the subject’s selection of bet option or not. As is seen in Fig. 4, the subjects consistently placed larger bet in the positive emotional load session than in the negative emotional load session, although this difference was slightly below the statistical significant level (ANOVA, $F_{1,26} = 4.12, p = 0.053$).

We analyzed the reason why the subjects consistently selected a larger amount of bet in the positive load session. In the present study, many positive words and a few neutral and negative words were included in the positive load session, whereas many negative and a few neutral and positive words were included in the negative load session. Therefore, we examined whether the subject’s selection of bet option was affected by the difference of emotional load sessions (positive vs. negative) or the difference of emotional words (positive vs. neutral vs. negative) needed to memorize in each trial. In other words, we classified the subject’s amount of bet in terms of which session the subject was performing

![Fig. 4. The subject’s selection of bet option in the CGT. Color ratio indicates the ratio of pink vs. blue boxes (pink:blue). Gray solid and dotted lines indicate the results obtained under the positive or the negative emotional load sessions for each subject, respectively. Black solid and dotted lines indicate between-subject averages under two emotional load sessions. Error bars: s.e.m.](image-url)
(emotional load session, positive vs. negative) and which of the emotional words the subject was remembering in that trial (emotional word condition, positive vs. neutral vs. negative), and carried out a two-way ANOVA. This analysis revealed that there was no interaction of the emotional load sessions and emotional word conditions \((F_{2,52} = 0.14, p = 0.775)\). Also, the main effect of emotional load session became non-significant \((F_{1,26} = 0.35, p = 0.557)\). However, significant difference in the amount of bet among three different emotional word conditions was observed (ANOVA, \(F_{2,52} = 17.03, p < 0.001\)) (Fig. 5). Subjects tended to select a larger bet option when positive word was remembered during the trial. The mean of the selected bet was 55.1 ± 18.0 (SD) % in trials with memorization of positive words, 49.9 ± 17.5% in trials with memorization of neutral words, and 48.4 ± 17.3% in trials with memorization of negative words. Significant differences were present between the positive and the neutral word conditions and between the positive and the negative word conditions (Shaffer’s method, \(p < 0.001\)). But, there was no significant difference between the negative and the neutral word conditions. Thus, the subjects tended to place larger bet when positive word was remembered during the trial. This result indicates that some processes necessary to perform the CGT are affected by emotional distracters.

**Fig. 5.** Effect of emotional words on the subject’s selection of bet option. Gray solid and dotted lines indicate the results obtained under the positive or the negative emotional load sessions for each subject, respectively. Black solid and dotted lines indicate between-subject averages under two emotional load sessions. Error bars: s.e.m.
Results of Iowa Gambling Task (IGT)

As is commonly used for the analysis of IGT performances (Bechara et al., 1994; Bechara, Tranel, et al., 2000), we calculated the IGT score by subtracting the number of card selections from deck A and B from the number of card selections from deck C and D for each block of 20 trials. High IGT score indicates that the subject selected a large number of cards from advantageous card decks, whereas low IGT score indicates that the subject selected more cards from disadvantageous card decks. One way repeated measures ANOVA revealed that the subject’s IGT score gradually increased as the task progressed ($F_{4,104} = 24.35, p < 0.001$). The multiple comparisons using Shaffer’s method supported this observation. These results indicate that most subjects learned to select the card from advantageous card decks as the task progressed. This is consistent with the previously reported normal subjects’ performances in the IGT (Bechara et al., 1994; Bechara, Tranel, et al., 2000).

Relations Among the IGT Score, Indices of the STAI, and the Subject’s Bet in the CGT

We examined whether or not IGT score and the SA and the TA scores of the STAI correlated to the magnitude of the emotional effect in the CGT. The magnitude of the emotional effect in the CGT was obtained by subtracting the mean amount of bet in the trials in which neutral or negative emotional words were needed to be memorized from the mean amount of bet in the trials in which positive words were needed to be memorized. Statistically significant correlation was not observed among the magnitude of the emotional effect in the CGT, the IGT score, and two scores of the STAI. This result indicates that the effect of emotional distracters on the selection of bet option in the CGT is not directly related to two anxiety properties of the subject, nor the IGT score.

DISCUSSION

In this study, we observed an effect of emotional distracters on the process of cognitive decision-making, using a modified version of the CGT. The quickness and the quality of decision-making didn’t differ among trials in which the subject needed to remember either emotional or neutral words, but the subject’s amount of bet was significantly increased when the subject needed to remember positive emotional words. Although the optimal selection of bet option is an important feature to earn as much money as possible in the CGT, the subjects tended to make riskier selection when they remembered positive emotional words, indicating that the emotion is a factor which affects the process of the cognitive decision-making.

Emotional Effect on Cognitive Decision-Making

Human decision-making have been studied in the frameworks of cognitive and emotional decision-making, which are relatively independent forms of decision-making (Brand et al., 2006). The cognitive decision-making is thought to be performed under risky situations, in which the payoff and the probability of every option are explicitly
known to the subject. On the other hand, the emotional decision-making is thought to be performed under ambiguous situations, in which information about options is not fully provided. Historically, economists have long been interested in how a human can make a rational decision under a variety of risky situations (Bernoulli, 1738). Most studies investigated what the economically advantageous decision-making is in terms of the expected values and utilities of each option. Thus, early studies of decision-making were focused on the mechanisms of cognitive decision-making (Knight, 1921).

The CGT has been used as a typical task requiring cognitive decision-making. Although risky decision is needed when performing the CGT, the payoff and its probability of every option are explicitly informed to the subjects. Thus, subjects can make the most advantageous decision based on known payoffs and known probabilities of choice options. Therefore, decision-making in the CGT can be performed rationally without emotional influence.

However, recently, more attention is paid toward the emotional aspects of human decision-making. Many studies have revealed that the emotion strongly affects cognitive functions such as attention (Bishop, Duncan, Brett, & Lawrence, 2004; Bishop, Duncan, & Lawrence, 2004; Fox, 1993), language (Schacht & Sommer, 2009), and working memory (Gray, 2001). Therefore, whether or not cognitive decision-making is also affected by emotion becomes an important issue. However, the emotional effect on the CGT has not yet been examined directly.

In the present study, we investigated whether the performance of the CGT was affected by emotional distracters by introducing a modified version of the CGT which combined with short-term word memory task. The subjects were required to remember either emotional or neutral word along a trial and recall it at the end of each trial. We used positive or negative emotional Japanese words as emotional distracters. As a result, subject’s betting behavior was affected by these emotional distracters. Subjects tended to bet significantly larger amount of money when they were asked to memorize positive emotional words compared to neutral and negative words. However, emotional distracters had no effect on the subject’s selection of one of two colors and on the subject’s quickness of selection. The anxiety scores measured by the STAI and the IGT score indicate that all subjects used in the present study showed similar values as were observed in normal subjects and ordinary Japanese university students. These results indicate that the performance of the CGT is affected by the emotion in normal subjects. In the present study, the subject’s selection of bet option is the only parameter of the CGT performance affected by emotional distracters, but it is a critical process to accumulate money as much as possible in the CGT. Therefore, it could be concluded that the emotion plays a critical role in the CGT performance.

The results of the previous studies using patients with frontal variant fronto-temporal dementia (Rahman, Sahakian, Hodges, Rogers, & Robbins, 1999; Rahman et al., 2006), patients with aneurysms of the anterior communicating artery (Mavaddat, Kirkpatrick, Rogers, & Sahakian, 2000), and patients with lesions including ventromedial or orbital prefrontal cortices (PFC) (Clark, Manes, Antoun, Sahakian, & Robbins, 2003; Clark et al., 2008; Rogers, Everitt et al., 1999) suggested that the betting behavior in the CGT seems to
be a sensitive indicator of abnormal decision-making in these patients. Therefore, the altered betting behavior shown by frontal patients and its biological mechanism might be a clue for the future studies investigating the neural mechanisms of emotional effects on the cognitive decision-making.

**Difference of the Emotional Effect Between the CGT and the IGT**

Previous study by Hinson et al. (2006) investigated the emotional effects on the performance of the IGT. They requested human subjects to perform the gambling task analogous to the IGT simultaneously with a short-term memory task of emotional words which was not directly related to the gambling performances. They found that the task-nonrelated memorization of emotional words did affect the subject’s preference to the decks. The subjects showed higher scores throughout the task when positive words were presented in the most of trials (positive load session), whereas the subjects showed lower scores throughout the task when negative words were presented in the most of trials (negative load session). The effect of the emotion on the IGT performance was apparent between these sessions. This study by Hinson et al. (2006) clearly indicated the effect of emotional distraction on the IGT performance.

In the present study, on the other hand, the effect of emotional distracters in the CGT performance was not apparent among different emotional load sessions. However, this effect was evident when we compared the amount of bet among trials in which positive, neutral, or negative word was required to memorize. Subject’s amount of bet was higher when remembering emotionally positive word during a CGT trial compared with when remembering emotionally neutral or negative word. This is an important difference of emotional effect between the IGT and the CGT. Our present result indicates that the effect of the emotional distracter in the CGT performance was observed across trials, whereas, as Hinson et al. (2006) indicated, the emotional effect in the IGT performance was observed across sessions. In addition, no significant correlation was observed between the selection of the bet in the CGT and the STAI scores, suggesting that the subject’s decision was affected not by the general emotional trait or state such as mood or motivation maintained during sessions, but probably by more short-term emotional fluctuation changing from moment to moment.

**Comparison of Task Properties Between the CGT and the IGT**

Since the first description by Bechara et al. (1994), the IGT has been widely used for examining the mechanism of decision-making in a large number of studies. The series of the studies by the Damasio’s group indicated the importance of the ventromedial and orbital PFC in the performance of the IGT (Bechara et al., 1994; Bechara, Tranel, Damasio, & Damasio, 1996; Bechara, Damasio, Tranel, & Damasio, 1997; Bechara, Damasio, Tranel, & Anderson, 1998; Bechara, Damasio et al., 2000; Bechara, Tranel et al., 2000; Bechara & Damasio, 2005; Damasio, 1996). However, the first argument about the importance of the ventromedial and orbital PFC in the IGT performance was brought from the observed overlaps, not restriction, of the lesions of the patients with low IGT scores (Bechara et al., 1994, 2005). Furthermore, whether or not additional components
such as the reversal learning (Maia & McClelland, 2004), working memory (Hinson et al., 2002; Jameson et al., 2004), and executive functions (Turnbull, Evans, Bunce, Carzolio, & O’Connor, 2005) are necessary to consider the IGT performance is the matter of debate. Thus the interpretation of the experimental results using the IGT is still being discussed and the consensus regarding the responsible brain areas and the necessary cognitive components to perform the IGT is not brought yet.

On the other hand, the CGT has the advantage of its low demands for the working memory and reversal learning, since the selections of the color and the bet option in each trial are completely independent. Imaging and magnetic stimulation studies which used an analogous task to the CGT (i.e. Risk Task) reported the involvement of the orbital PFC and the inferior lateral parts of the PFC in the CGT performance (Knoch et al., 2006; Rogers, Owen et al., 1999; Rubinsztein et al., 2001). The patients with frontal lobe injuries and low IGT scores also exhibited a mild impairment to the CGT performance (Clark et al., 2003; Manes et al., 2002). Moreover, one study recently revealed that the lesion in either the ventromedial PFC or the insular cortex caused impaired CGT performance (Clark et al., 2008). These studies indicate that the ventromedial and orbital PFC participate in both CGT and IGT performances, suggesting that the neural components responsible for the emotional decision-making are overlapped with those for the cognitive decision-making.

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