Emotion-based learning on a simplified card game: The Iowa and Bangor Gambling Tasks

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Accepted 12 February 2004
Available online 13 April 2004

Abstract

The Iowa Gambling Task (IGT) has been widely used in the assessment of neurological patients with frontal lesions. Emphasis has been placed on the complexity of the task (i.e., four decks of varying contingency pattern) with the suggestion that the participant must use emotion-based learning to deal with a complex decision-making process. The present study used a single deck card game (the Bangor Gambling Task, BGT), matched in many respects with the Iowa Gambling Task, in which the contingencies varied over time (gradually becoming worse for the participant) rather than across deck (as in the IGT). Forty participants performed both tasks. Performance on the tasks showed many similarities, with participants showing a comparable pattern of incremental learning on both tasks, reaching an analogous final level of performance. More importantly, there was a high correlation ($r^2 = .93$) in performance between the two tasks, the most salient feature of which was that virtually every participant who fell below Bechara et al.’s (2001) categorisation of impaired IGT performance, also did very poorly on the BGT. These findings bear on the question of whether arguments about the complexity of the Iowa Gambling Task necessarily explain why it appears to require emotion-based learning. The Bangor Gambling Task might also be a useful tool for clinical neuropsychologists, in the assessment of patients with executive dysfunction—given that the task is easier and quicker to administer than the Iowa Gambling Task, but appears to share the same performance features.

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1. Introduction

The Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994) has been widely used in the assessment of neurological patients with ventromesial frontal lesions, where it is argued to measure the role of emotion in decision-making, and demonstrates the extent to which learning based on emotion systems is useful in dealing with complex problem-solving situations (Bechara et al., 1994). Patients with ventromesial frontal lesions typically do well on standard tests of intelligence, and often show near-normal performance on a range of ‘executive’ tasks. However, they choose unsuitable friends, enter inadvisable relationships, and engage in ill-advised activities (Bechara et al., 1994, 2000a). This behaviour rapidly leads to financial losses, career termination, and loss of affection of family and friends. It has been proposed that these poor judgement and decision-making abilities in social cognition follow from an inability to use ‘somatic markers’—i.e., emotion-based knowledge about the possible outcome of decisions (Damasio, 1994, 1996).

There are several lines of argument which support the Bechara et al. claim that the Iowa Gambling Task represents a test of emotion-based learning. For example, the fact that participants show reliable modifications in skin conductance (e.g., Bechara, Damasio, Damsio, & Lee, 1999), and that the task is failed by patients with lesions in the ventromesial frontal region (e.g., Bechara et al., 1994, 2000b)—which is a known conduit for pathways from emotion systems to the dorso-lateral prefrontal cortex (Panksepp, 1998). However, the possible role of emotion-based learning on the task is also bolstered by findings of the role of various memory systems (Bechara et al., 1994, 1998).
finding of a double dissociation between performance on a measure of working memory, and the Iowa Gambling Task, in patients with (ventro-medial versus dorso-lateral) frontal lobe lesions (Bechara, Damasio, Tranel, & Anderson, 1998). An important aspect of the Bechara et al. argument about the role of emotion systems in decision-making is derived from arguments about task complexity. The Iowa Gambling Task data (Bechara et al., 1994, 1998, 2000a) suggest that emotion-learning systems operate on an ‘aggregate-learning’ principle, such that they provide information (in terms of a weighted average) about the often long and complex reinforcement history which the individual has had with an object. In contrast, working memory systems have a limited capacity for holding information, making them inappropriate for following the complexities of real-world decision-making. Thus, for the Iowa group, the Gambling Task is seen as reflecting the complex nature of decision-making. For example, Damasio claims that “there is no way for players to carry out a precise calculation of gains and losses. Rather, bit by bit, they develop a hunch that some decks...are more ‘dangerous’ than others” (Damasio, 1994, p. 213). This argument about the importance of complexity in the Iowa Gambling Task was supported when participants were questioned on their explicit recall of the cards they had turned. Bechara et al. reported that “a group of normal control subjects with superior memory and IQ...could not provide calculated figures of the net gains and losses from each deck” (1994, p. 13).

Thus, an important part of the claim that the Iowa Gambling Task is a measure of emotion-based learning, has been the fact that the task is complex—because it has multiple decks and varying contingencies. However, there is a strand of the literature, originating outside of neuropsychology, which uses card-based gambling tasks, that show variations in contingency-relationships, but are substantially less complex than the Iowa Gambling Task. Perhaps, the best known is that of Newman, Patterson, and Kosson (1987), who designed such a task to assess response perseveration in psychopaths. It was found that once such individuals developed a ‘response set’ for reward, they had difficulty in shifting from a previously successful pattern of reward seeking which had become unfavourable.

The Newman et al. (1987) task involved a deck of 100 cards. In the first block of 10 cards, only a very small punishment was incurred, but the probability of losing money was raised by 10% with each block of 10 card turns. Participants could choose to terminate the game at any time, though the longer the game continued, the more money they would lose. On average, individuals in the psychopathic group made nearly 90 card selections before terminating the game, whereas the control group (incarcerated non-psychopathic males) turned on average just over 60 cards before opting out.

It seems that the basic nature of the Newman et al. (1987) task shares much in common with the Iowa Gambling Task: Principally that it is a gambling card task, with an explicit financial reward/punishment component, and variation in the contingency relationship (across space in the Iowa Gambling Task, and across time in the Newman et al. task). It is also of some interest that psychopathic individuals should perform poorly on this task, given that several recent studies have demonstrated that psychopaths perform poorly on the Iowa Gambling Task (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Blair, 2001; Damasio, 2000; Schmitt, Brinkley, & Newman, 1999).

In this context, the present study asked a group of participants to perform the Iowa Gambling Task (IGT), and the Bangor Gambling Task (BGT, a modified version of the Newman et al. measure). The tasks would appear to have similar properties if: (a) a similar pattern of learning was shown on both measures, and (b) there was a high correlation in performance between the two (such that those who did poorly on the IGT also did poorly on the BGT). If the two tasks appear to be tapping the same psychological functions, this has implications for the Bechara et al. claim that the complexity of the Iowa Gambling Task is a central reason for its ability to measure emotion-based learning.

2. Methods

2.1. Participants

Forty undergraduate students from the University of Wales, Bangor were recruited, and each received course credit for participating. In addition, participants were allowed to keep any money they won. The mean age of participants was 20.4 years, there were 28 females and 12 males. All participants took part in two tasks: The Iowa Gambling Task (Real Money version), and the Bangor Gambling Task, in a counter balanced sequence.

2.2. The Iowa Gambling Task

The procedure was identical to the original Bechara et al. (1994) study, except that the task employed the Real Money reward system (Bowman & Turnbull, 2003, see below for details). As in Bechara et al. (1994), participants could choose any card from the four decks (labelled A, B, C, and D) in any sequence. Decks A and B were disadvantageous, and C and D advantageous, though the schedule of reward and punishment differed. In Deck A (bad deck) and Deck C (good deck) there were five smaller unpredicted punishments per ten card selections (thus twenty punishments in total for each deck). On Decks B and D there was only one punishment per ten card selections, which was equal in size to
the total 10-card loss on Decks A and C. The only substantial difference in administration from that of Bechara et al. was the value of the reward and punishment (and the fact that the currency was Pounds rather than Dollars). Participants played for real money, at a ratio of $1000: £1 (see Bowman & Turnbull, 2003). Thus, participants were given £2.00 worth of real money at the beginning of the game (versus $2000 on the Bechara et al. task). For the disadvantageous decks (A and B), participants won 10p for every card turn, incurring losses of between 15p and £1.25. On the advantageous decks (C and D), participants won 5p for every card turned, incurring losses of between 2p and 25p. Participants were informed at the start of the game that they could keep any money they won. We have previously demonstrated (Bowman & Turnbull, 2003) that there is no significant effect on performance of the real versus facsimile payment system. Our original study (Bowman & Turnbull, 2003) showed that participants were marginally (but non-significantly) more cautious in gambling real money in the middle blocks of the task, but showed patterns identical to the facsimile condition by the end of the task.

2.3. The Bangor Gambling Task

A deck of 100 regular playing cards, consisting of 38 ‘high’ cards (that is, Jack, King, Queen, or Ace) and 62 ‘low’ cards (that is, cards between 2 and 10) were sequenced to create a pattern of winning and losing streaks. Fifty black cards and 50 red cards were used, and there were equal numbers of card suits (25 Spades, 25 Clubs, etc.). Each card was affixed with a label (on the face/number side) representing a monetary loss or gain, corresponding to one of four values (win 20p, win 10p, lose 20p, lose 10p). These financial levels are matched to the Real Money version of the IGT (Bowman & Turnbull, 2003), see above. As with the original Newman task, ‘high’ cards produced financial gain, where an Ace or King represented a win of 20p, and a Queen or Jack represented a win of 10p. Number cards 2–5 produced a loss of 20p, and cards 7–10 a loss of 10p. Number cards 2–5 produced 20p losses on 50% of turns, with 10p losses on the other 50% of turns. In total there were 9 of the +20p cards, 29 of the +10p cards, 35 of the –20p cards and 27 of the –10p cards. Suit and card value was evenly distributed across each of the four types of punishment and reward. In addition, a further 50 cards (independent of colour or suit) were placed below the deck the player selected from. These were ‘redundant’ cards used to avoid participants predicting when the game was going to end. £7.00 worth of real money was used (70 × 10p), and a score sheet was constructed to monitor the pattern of wins and losses over the game.

At the start of the game all participants were given £2.00 (20 × 10p’s) and told that any money they won, they could keep. Participants were given written instructions informing them that the aim of the game was to lose as little of the £2.00 as possible and to make as much on top of that as possible. They were instructed that the deck of cards was not a regular deck (to avoid participants expecting all to be equal if they kept gambling) and that if they selected wisely they would be able to win money.

Most importantly, participants were told that they had to make a certain number of card turns and that the experimenter would tell them when the game was over. However, it was entirely at the discretion of the player when to gamble and when not to gamble. Participants were told that they could gamble as often as they liked, and should not feel under any pressure to gamble (or not) just because a certain number of cards had to be turned. It was explained to participants that, before selecting a card from the top of the deck, they had to clearly state whether they would gamble on it (or not), and participants were also informed that if they chose not to gamble then their money would be unaffected by the outcome of the card. However, if they did choose to gamble on a card then they would win or lose according to the card they turned.

The deck of 100 playing cards (unbeknownst to participants) was split into five blocks of 20 card selections (as in the IGT). A schedule of wins and losses was created so that at the start of the game (Block 1), had participants gambled on every card they would have gained £1.00 (15 win cards and 5 loss cards). In Block 2, if participants gambled on every card, they would neither gain nor lose any money (10 win and 10 loss cards); in Block 3 participants faced 5 win cards and 15 loss cards, thus equating to a loss of £1.00 if they gambled on every card; Block 4 again consisted of 5 win and 15 loss cards, but the value of the loss cards was higher, and the value of the win cards lower, so that participants stood to lose £2.00 if they gambled on every card; in the fifth and final Block there were 3 win cards and 17 loss cards, incurring a loss of £3.00 if every card was gambled on. Thus, the punishment for gambling increased with each block (as in Newman et al., 1987; though on a different schedule).

Thus, the BGT plays different contingencies across blocks off against one another, with contingency shift across time. In contrast, the IGT plays different contingencies across decks off against one another (contingency shift across space). The BGT therefore presents itself as a much simpler task, in that it does not depend on the ability of participants to calculate differences in contingencies between decks, and it does not afford participants the opportunity to seek future financial reward in payment for more conservative, yet advantageous card selections. However, it retains all the ingredients required for a tool to assess real-life decision making in a laboratory environment, as defined by
Damasio, who described the IGT as: “Carried out in real time and resembles regular card games. It factors in punishment and reward, and overtly includes monetary values. It engages the subject in a quest for advantage, it poses risks, and it offers choices, but does not tell how, when or what to choose” (Damasio, 1994, p. 215). As in the IGT, the BGT is loaded with uncertainty—because a new pattern of contingency is regularly modified, so that participants must respond to changing environmental circumstances (much as they would have to in real-life) without any formal warning of such changes. Thus, as in the IGT, it would be expected that neurologically normal individuals performing the BGT would be risk-averse enough to inhibit card selecting when punishment increases sufficiently to provide the real possibility that all money will be lost. This should generate aversive advance warning signals, akin to those seen in the IGT when participants begin to avoid the ‘bad’ decks (Bechara et al., 1998).

Performance on the BGT was calculated (as in the standard IGT scoring scheme, Bechara et al., 1994) as the number of good selections minus the number of bad selections made per block and overall. To map on to the IGT scoring scheme, a good selection was considered to be when a participant chose not to gamble, and a bad selection was when a participant did choose to gamble. A slight discrepancy arises here, in comparing the BGT and IGT. On the BGT, to gamble in the first block is actually advantageous to participants. However, as in the IGT, participants would have no way of knowing this without first sampling the cards. In effect then, the first 20 selections in the BGT correspond to the first 20 selections of the IGT, which are considered as disadvantageous/advantageous even before participants have any way of judging this.

One hundred card selections had to be made in order for comparison with the IGT. Thus, any participant who lost all of their money before making 100 card selections was given a further £1.00 in order that they could continue the game. Any participant who required the further £1.00 was again informed of the aims of the game.

Twenty participants played the IGT first, and 20 played the BGT first. Each participant was tested on the same day, over a 1 h session, with the IGT lasting 20–30 min, the BGT lasting 15–20 min, with a 10 min break separating both gambling tasks.

3. Results

For both the gambling tasks, the 100 card selections were divided into five blocks; selections 1–20, 21–40, 41–60, 61–80, and 81–100. For the IGT (as in Bechara et al., 1994) the net score for each block was calculated as number of good selections minus number of bad selections across decks ((C + D) − (A + B)). In the BGT the net block scores were calculated as the total number of bad selections (cards gambled on) subtracted from the total number of good selections (cards not gambled on) within each block. A net score below zero implied that participants were selecting disadvantageously, and a net score above zero corresponds to advantageous selection.

Participants were selecting advantageously by the second block in the IGT, and by the third block on the BGT. With the exception of the difference between Block 2 of each task, performance on the BGT and IGT followed a similar pattern across the span of the game (see Fig. 1).

A within-subjects ANOVA revealed a main effect of Block, \( F(156,4) = 51.49, p = .001 \), but no main effect of Task, \( F(39,1) = 2.01, p = .164 \). A significant interaction between Block and Task was found, \( F(156,4) = 3.13, p = .016 \), prompting further analysis using post hoc \( t \) tests. Paired \( t \) tests were run on Block 2 and Block 3. There was a significant difference between tasks on Block 2 \( (t(39) = 3.67, p = .001) \), but there was no significant difference between tasks on Block 3, \( (t(39) = 2.05, p = .047 \), non-significant when a Bonferroni correction was made).

Overall scores in the BGT and IGT were also calculated. In both cases, such scores were gained by subtracting the total number of good minus bad selections across the entire 100 card selections. A paired samples \( t \) test was run using overall scores for each condition, but there was no significant difference between tasks \( (t(39) = −.88, p = .384) \). The mean score for the BGT was 13.2 (SD = 22.4) and the mean score for the IGT was 14.9 (SD = 12.2).

A Pearson product-moment correlation was performed on the overall individual scores calculated for each task. This analysis revealed a high positive correlation between BGT performance and IGT performance \( (r^2 = .93, p < .001) \), Fig. 2.

![Figure 1. Mean number of good-bad card selections, per block, for Bangor (BGT) and Iowa (IGT) Gambling Tasks. Variance is represented as one standard error.](image-url)
The present study suggests that a single-deck variable-contingency measure of gambling, the Bangor Gambling Task (BGT), operates in many ways like the more widely used multiple-deck constant-contingency Iowa Gambling Task (IGT). The most obvious feature of this compatibility is the fact that participants showed an incremental learning profile on the BGT, of the same general trajectory seen on the IGT (Fig. 1). The IGT and the BGT also produced similar overall mean scores (13.2 and 14.9, respectively), suggesting that the overall structure of the task is similar. Indeed, the overall mean scores for the BGT and IGT are closer than a previous comparison between the IGT itself, when run under ‘real’ and ‘facsimile’ money conditions ($M = 14.76$ and $M = 20.12$, respectively; Bowman & Turnbull, 2003). This finding does not, in itself, suggest that the two tasks measure the same psychological phenomena, but it does demonstrate that the overall design properties of the two tasks are similar—not only in that they are 100-trial gambling card tasks, but also that the tasks offer a similar distribution of reward and punishment to the participant.

More importantly, individual performance on the two tasks was strikingly similar. For example, 14/40 (35%) participants performed within the range exhibited by patients with ventromesial frontal lesions (calculated as completing the game with a total score of +9 or less) on the IGT (Bechara et al., 2001). Of these 14 individuals, all also performed at +9 or below on the BGT, such that failure on the BGT was highly predictive of poor IGT performance (Fig. 2). Only one participant would not have been classified as performing below the Bechara et al. (2001) ‘cut-off’ on both tasks. Notably, this individual scored +8 on the BGT, and +10 on the IGT.

There was also a high correlation in performance between the two measures ($r^2 = 0.93, p < .001$), which suggests that the similarities between the two tasks do not lie only in the lower end of the range, but that the psychological variables underlying performance of the IGT and BGT are similar for all levels of performance. In many respects, a high correlation is unsurprising, given that both tasks have a number of common properties: Such as the fact that both measures are 100-trial card-based gambling tasks, which involve the active reward and punishment element of a financial transaction, using a ‘real-money’ format (Bowman & Turnbull, 2003) that emphasises the emotion-based nature of the task.

However, the tasks differ in only a single obvious dimension—that of the number of decks. Given that Bechara and Damasio have both stressed the importance of complexity in the Iowa Gambling Task (see the Introduction above), this is a somewhat surprising result. It might have been expected, for example, that a simpler version of the Iowa Gambling Task would have allowed participants to employ explicit episodic recall, and working memory resources, in performance of the Bangor Gambling Task. Emotion-based learning and working memory resources are known to be functionally independent (Bechara et al., 1998) on the IGT, and one would not automatically expect that those who have strengths in the one domain will be strong in the other. Thus, one would not necessarily expect a high correlation in performance between the two tasks and yet the present study found a correlation of greater than 0.9, suggesting that the two tasks share much in common as a measure of emotion-based learning.

There is a further implication of the present study, with regard to the clinical investigation of patients with executive dysfunction. Numerous studies have demonstrated that the Iowa Gambling Task is effective in providing quantitative evidence of the poor performance of patients with ventromesial frontal lesions (e.g. Bechara et al., 1994; Bechara & Damasio, 2002). However, no simple bedside version of the task has yet been developed. One reason might be the practical difficulty of administering a four-deck card task, together with various piles of facsimile money, to patients in a clinical setting. There is also the issue of the complexity of the instructions and feedback on the standard version of the IGT, which involve both wins and losses on each trial, not to mention the fact that the task also takes some 20–30 minutes to administer. Thus, there are many practical advantages in using a single-deck version of the task (including administration time), providing that it captures the same psychological phenomenon (emotion-based learning) as the original Iowa Gambling Task. The validity of this enterprise will depend on whether...
the Bangor Gambling Task shows the same performance properties when used with neurological patients. Nevertheless, the present study represents a preliminary step in establishing whether the Bangor Gambling Task may well be a useful clinical tool in the assessment of executive function.

Acknowledgment

We would like to thank Jordan Grafman for his suggestions about the possibility of a single-deck Gambling Task.

References


