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Effects of decision-phase time constraints on emotion-based learning in the Iowa Gambling Task ☆

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Abstract

Research employing the Iowa Gambling Task (IGT) has frequently shown that learning is impaired in various clinical populations. However, precisely what constitutes ‘‘unimpaired’’ control group learning remains unclear. In order to understand some of the possible factors underlying variability in control group IGT performance, the present study sought to manipulate features of the task to intentionally *disrupt* learning. Specifically, the present study investigated the effects of time constraints on emotion-based learning during automated administration of the IGT. For two groups of participants, a time-constraint of either 2-s or 4-s was implemented during the critical decision making period, while a control group received no time constraint. We also evaluated participants' subjective experience after every block of 20 trials. Results demonstrated that the 2-s group differed significantly from the control group. Subjective experience measures revealed rapid development of awareness of the advantageous and disadvantageous decks among all three groups. Overall, our findings demonstrate, for the first time, the effects of decision-phase time constraints on emotion-based learning and indicate that the IGT reward/punishment schedules are to some extent cognitively penetrable.

Keywords: Iowa Gambling Task; Time constraints; Decision-phase; Subjective experience; Emotion-based learning

1. Introduction

Research on the Iowa Gambling Task (IGT) has grown dramatically ever since Bechara and colleagues published the results of their initial study in 1994 (Bechara, Damasio, Damasio, & Anderson, 1994). Since then, a number of studies have used the task to study executive functioning and decision making abilities in psychiatric (e.g., Cavedini et al., 2002; Dalgleish et al., 2004; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2005; Ritter, Meador-Woodruff, & Dalack, 2004), neurologically-impaired (e.g., Bechara, Damasio, Damasio, & Lee, 1999; Levine et al., 2005) and normally developing populations (e.g., Balodis, MacDonald, & Olmstead, 2006; Bowman & Turnbull, 2003; Fernie & Tunney, 2005; Pecchinenda, Dretsch, & Chapman, 2006).

The IGT typically consists of five blocks of 20 trials, and involves participants making choices from four concurrently available decks of cards for monetary gain/loss. Two of the decks (labelled A & B) result in frequent immediate high gain per choice (e.g., £100), but produce regular losses, leading to a cumulative long-term loss (i.e., termed ‘‘the disadvantageous choice’’). The remaining two decks (labelled C & D) typically result in lower immediate rewards, (e.g., £50), but also generate fewer losses, resulting in a cumulative long-term gain (i.e., termed ‘‘the advantageous choice’’). A defining feature of performance on the IGT is the gradual adjustment to the affective consequences of reward and punishment, as participants initially sample cards from all of the decks before showing, around halfway

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through the task, a choice preference for the advantageous decks (Dunn, Dalgeish, & Lawrence, 2006; Turnbull, Evans, Bunce, Carzolio, & O'Connor, 2005).

While it has more or less consistently been shown that learning on the IGT is impaired in people with brain lesions and psychiatric disorders (e.g., Bechara et al., 1994; Ritter et al., 2004), exactly what constitutes "unimpaired" learning remains to be determined (Dunn et al., 2006, p. 251). For instance, variability in IGT performance has been observed with some subgroups of healthy, control populations failing to show preference for the advantageous decks at the end of the task (e.g., Bechara & Damasio, 2002; Glicksohn, Naor-Ziv, & Leshem, in press; Lehto & Elorinne, 2003; see Dunn et al., 2006, pp. 251–252). These and other findings showing variability in control group performance on the IGT make interpretation of IGT data difficult because a normative or baseline control group profile is necessary in order to evaluate the performance of experimental (i.e., patient) groups. It is important then, that further research be undertaken to identify the factors that may influence advantageous control group IGT performance.

One possible way of examining variability in IGT performance would be to manipulate methodological features of the task in order to selectively *disrupt* advantageous choice making. According to this logic, if the manipulation successfully disrupts learning, as evidenced by a diminished preference for the advantageous decks, then a profile of unimpaired learning should be observed when the manipulations are absent or removed. This may then permit an analysis of the conditions needed to establish unimpaired learning in control groups, and help make the interpretation of data from IGT studies with clinical populations more reliable (Dunn et al., 2006).

This was the approach adopted by the present study. We were interested in determining whether or not imposing a time-constraint on IGT choices would disrupt the learning rates of a normally developing (i.e., undergraduate) population. Bowman, Evans, and Turnbull (2005) adopted a time-constraint of 6-s, which was based on the average inter-trial interval (ITI) developed by Bechara et al. (1999) to record skin conductance responses during automated administration of the IGT. Bowman et al. found no significant differences in IGT learning rates across three groups given either automated or non-automated formats, and with the time constraint implemented only during the automated administration. However, the time constraint employed by Bowman et al. was only operational during the ITI, and not while the four decks of cards were displayed. That is, once the ITI had elapsed, no time constraint was present during the critical decision making period. It is perhaps unsurprising then that learning rates did not differ significantly either between IGT administration formats or when a 6-s ITI was used (during the automated task).

Bowman et al. speculated that an enforced delay of 6-s might evoke feelings of frustration, with participants eager to make their card choices as quickly as possible in order to access the outcomes of their choices. Such unintended frustration *might* impact upon the IGT because it recruits emotion-based resources (Damasio, 1996; Dunn et al., 2006; Turnbull et al., 2005). As a result, the possible disruptive effects of time-constraints may be inferred from the subjective experience ratings the participants gave of the relative "goodness" and "badness" of the decks. However, Bowman et al. found no significant differences in the subjective ratings of each group—suggesting that the 6-s ITI did not evoke feelings of frustration. Notably, the 6-s ITI used by Bowman et al. (2005) was chosen in order to measure electrodermal responses, which have a slow time-course.

However, if the cognitive components of the task are of interest, it seems important to examine the potentially disruptive effects of *shorter* time constraints during the crucial decision making phase on IGT performance. A number of real-world situations have vital time constraints associated with them, most notably in the interpersonal world, when one often has only a few seconds to judge whether to make a joke, express sympathy at a loss, or respond to an aggressive challenge. In sum, there is much merit in considering the role of time-limitations on the IGT in shorter time durations, and focussing such time restrictions primarily at the crucial decision-making phase of the task.

In the present study, we sought to systematically investigate the effect of different time constraints implemented during the decision-making period using an automated IGT format. We selected to use decision-phase time constraints of 2-s and 4-s, respectively, and compared learning rates with those of a control group not exposed to any time-constraints. In addition to measuring behavioural performance, we also recorded participants' subjective experience ratings (e.g., Bowman et al., 2005; Evans, Bowman, & Turnbull, 2005) in order to examine the effects of time constraints on emotion-based learning with the IGT. We predicted that the two time constraints groups would show impaired learning in the IGT, relative to the control group, and that participants' subjective awareness of the "good" and "bad" decks would be unimpaired.

2. Method

2.1. Participants

Seventy-five participants, 23 male and 52 female, were recruited from the University of Wales, Swansea and randomly allocated to one of three groups: 2-s time constraint ($n = 25$), 4-s time constraint ($n = 25$), and a control group with no time constraint ($n = 25$). Participants' mean age was 21.6 years ($SD = 3$), with a mean of 15.7 ($SD = 2.17$) years spent in education (cf. Evans, Kemish, & Turnbull, 2004). No significant difference was found between the three groups for the above-mentioned characteristics. Following completion of the study participants were compensated with £5.

2.2. Materials and procedure

An automated version of the Iowa Gambling Task, programmed in Visual Basic® 6.0, was employed. Participants were instructed to select cards from four concurrently available blue-coloured decks (labelled sequentially A, B, C and D). The computer programme randomly determined which two of the decks were to be "advantageous" and "disadvantageous", respectively, for each participant. That is, unlike previous studies, the spatial location of the advantageous and disadvantageous decks was not restricted to the left (i.e., A & B) or right (i.e., C & D) of the computer screen.[1] Randomly determining advantageous and disadvantageous decks at the outset of the task for every participant rules out location preference as a potential factor governing performance. Once determined, the positions of the decks remained unchanged until the end of the task (cf. Pecchinenda et al., 2006).

A loan of £1000 of virtual money was displayed at the bottom right of the screen and was updated immediately following choices with gains and/or losses. Participants always won £100 if they selected a card from the "disadvantageous" decks and always won £50 if they selected a card from the "advantageous" decks. The amount of losses varied between £150 and £350 for deck A; £1250 for deck B; between £25 and £75 for deck C; and £250 for deck D. In the case of gains, a sentence stating, "You won X! X added to your total" appeared on the screen and the amount of money won was added to the total. In the case of gains and loss, the message presented was "You lose £1250! £1250 has been deducted from your total". This onscreen feedback was displayed for 10-s, before a 2-s ITI.

All three groups received general instructions about the task that were based on Bechara, Damasio, and Damasio (2000). The instructions given to the 2-s and 4-s time constraint groups differed from those of the control group in that speed of responding was emphasised ("Your task is to select one card at a time *as fast as you can*...").

In the 2-s and 4-s time constraint groups, gambling choices had to be made within a time limit of 2-s and 4-s, respectively. The 2-s and 4-s time constraints began counting down immediately upon the simultaneous presentation of the four decks of cards. If a choice was not made during the time available, then the screen cleared and a message saying, "Too slow!" was displayed for 5-s before the 2-s ITI. Trials in which a time out occurred (i.e., when a gambling choice was not made within the allocated time) were recorded but were not added to the ongoing trial total.

The task ended for all groups after 100 choice trials. Decision time, taken from the onset of the four decks until a choice was made, was also recorded for all participants.

[1] In keeping with convention (e.g., Bechara et al., 1994), we will continue to refer to the advantageous and disadvantageous decks as A & B and C & D, respectively, even though the labels corresponding to the good and bad decks were in fact randomly determined for each participant.

2.2.1. Subjective experience ratings

Similar to Bowman et al. (2005), after every block of gambling choices (where one block equals 20 trials), participants were asked to provide subjective ratings in terms of how "good" or "bad" they felt each deck to be. Ratings were made using a slider-scale from 0 to 10 (where 0 = *very bad* and 10 = *very good*).

3. Results

3.1. IGT mean net score

For the behavioural IGT performance measure, the mean net score was calculated by subtracting advantageous selections from disadvantageous selections [(C + D) − (A − B)]. A net score above zero is indicative of advantageous selections, while a net score below zero implies disadvantageous selections. Fig. 1 shows the IGT mean net scores for each of the three-groups. A mixed factor 3 (group) × 5 (block) ANOVA showed a main effect for block, $F(4, 288) = 27.03$, $p < .001$. All three groups showed a general increase in advantageous selections across trial blocks. There was also a significant main effect for group, $F(2, 72) = 3.83$, $p < .05$. Tukey HSD post hoc tests revealed that the control group made significantly more advantageous selections than the 2-s group ($p < .05$), but that the control group did not differ significantly from the 4-s group and that the 4-s group did not differ significantly from the 2-s group. The trial block by group interaction was not significant, $F(8, 288) = 1.18$, $p > .05$.

3.2. IGT and subjective ratings

A mean net subjective rating was calculated by subtracting the ratings of the advantageous decks from the subjective ratings of the disadvantageous decks. The mean subjective ratings for each group across block are shown in Fig. 2. A mixed factor 3 (group) × 5 (block) ANOVA showed a main effect for trial block, $F(4, 288) = 8.01$, $p < .001$. For the three groups, subjective ratings showed a substantial increase from the first to the second blocks of trials. The main effect for group and the group by trial block interaction were not significant, however.

3.3. IGT and decision time

Decision time was recorded for each IGT trial. Fig. 3 shows the mean decision time for each experimental group across the five trial blocks. A mixed factor 3 (group) × 5 (block) ANOVA found a significant main effect for trial block, $F(4, 288) = 5.62$, $p < .001$, a significant main effect for group, $F(2, 72) = 12.60$, $p < .001$ and a significant trial block by group interaction, $F(4, 288) = 3.22$, $p < .01$. Bonferroni-adjusted post hoc tests found that the control group had significantly longer decision times when compared to the 2-s group across the first three trial blocks ($p < .01$), and the 4-s group across the first two trial blocks

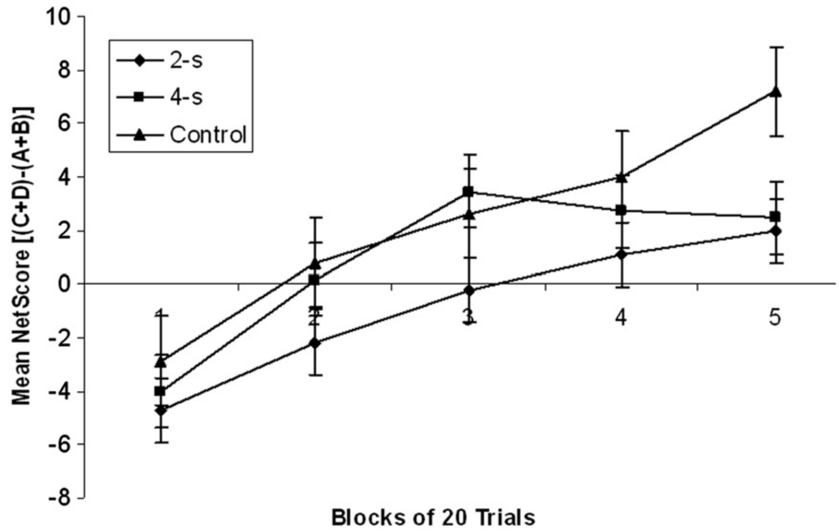

Fig. 1. Mean net scores for each of three groups across the five blocks of 20 trials.

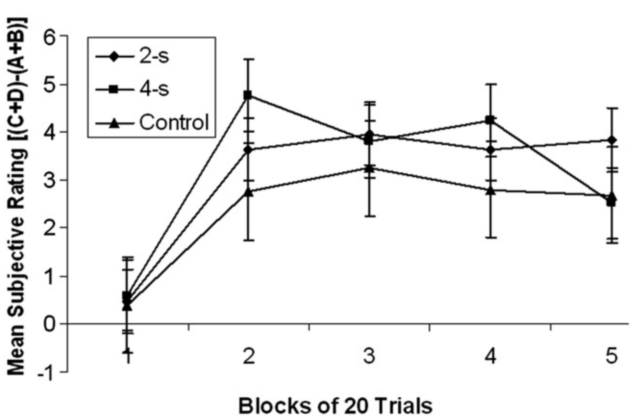

Fig. 2. Mean subjective experience ratings for each of the three groups across the five blocks of 20 trials.

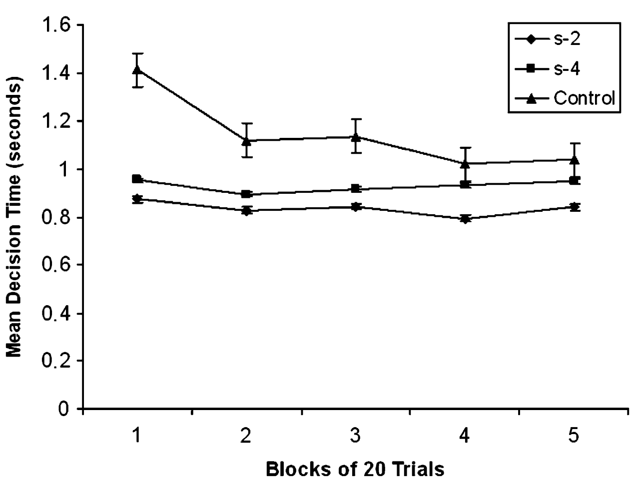

Fig. 3. Mean decision-time in seconds for each of the three groups across the five blocks of 20 trials.

($p < .01$). Further, the 4-s group had significantly longer decision times compared to the 2-s group in trial block four ($p < .01$). Fig. 4 shows the total number of "time outs" for all participants in the 2-s and 4-s groups. A 2 (group) × 5 (block) ANOVA showed a main effect for group, $F(1,48) = 17.42$, $p < .001$, while the main effect for block and the block by group interaction were not significant.

4. Discussion

The present study investigated the effect of 2- and 4-s time constraints on emotion-based learning during the critical decision-making period in the IGT, and found that learning was significantly disrupted compared with a control group given no time-constraints. All groups initially showed the typical pattern of decision-making below chance but gradually shifted to advantageous above-chance levels as the task progressed. This is consistent with other research from our laboratory (e.g., Cooper, Dymond, Whitney, & Cella, in preparation) and with previous research conducted with normal (i.e., undergraduate) populations (e.g., Balodis et al., 2006; Bowman & Turnbull, 2003; Fernie & Tunney, 2005; Glicksohn et al., in press). While all three groups showed an increase in advantageous decision making across trials, only the performance of the control group and 2-s group differed significantly. As such, the present findings are the first to show a significant disruptive effect of decision-phase time constraints on learning during the IGT (cf. Bowman et al., 2005), with less advantageous choices being made while performing the task under the 2-s time constraints.

Subjective experience ratings also showed a significant increase across blocks, for all groups. However, participants' ratings of which decks were "good" or "bad" did not appear to be disrupted by the implementation of time-constraints during the critical decision making period. That is, participants from all three groups showed comparable recruitment of emotion-based resources in discriminating

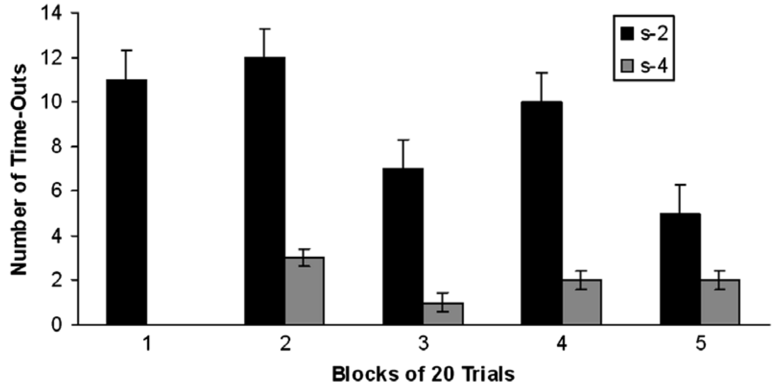

Fig. 4. The number of trial time outs for the 2-s and 4-s groups across the five blocks of 20 trials.

the advantageous decks at above chance levels from the first block of trials onwards. This suggests that participants had better awareness of the affective status (or emotion biased signals), of the reward and punishment schedule contained within the IGT than has previously been thought (cf., Bechara et al., 2000; Bechara, Damasio, Tranel, & Damasio, 1997; see Bowman et al., 2005; Evans et al., 2005; Maia & McClelland, 2004).

Our findings are relevant to the issue of the apparent "cognitive impenetrability" (Dunn et al., 2006, pp. 245–249) of the IGT schedules of reward/punishment because they show that participants can access emotion-based knowledge of the "goodness" and "badness" of the decks at a surprisingly early stage in the task, provided that participants are required merely to interrogate their feelings about an object (deck) rather than provide a fully-fledged descriptive account of the basis of the task (Evans et al., 2005; Maia & McClelland, 2004; Turnbull, Berry, & Bowman, 2003). Whether or not the subjective experience ratings measured in the present study can be said to accurately reflect the penetrability of the IGT reward and punishment schedules is, of course, a contested issue and one that must await the outcome of further research, as well as a greater conceptual clarity about the nature of conscious awareness.

The present findings also include the first published analyses of reaction time data during IGT performance, and show both significant main effects and interactions of trial block and participant group. As one might expect, the control group took significantly longer to make choices compared to the two time constraint groups, but the reaction times of all three groups were remarkably similar and remained below 2-s across all blocks of trials. Also perhaps unsurprisingly, there were a significantly greater number of "time outs" in the 2-s time-constraint group compared with the 4-s group, notably in the first and s blocks of trials. Taken together, the reaction time and time-out data indicate that decision-phase time constraints initially disrupt advantageous performance, in contrast to the fact that such constraints are not disruptive when imposed *between* decision-making phases (Bowman et al., 2005). Nevertheless, while decision-phase time constraints do produce a decrement in both speed and "accuracy", our participants still showed some adaptability to the reward/punishment schedules. The initial disruption in performance followed by a reduced, yet increasingly advantageous rate of learning in both time constraint groups resembles interventions from the applied behavioural psychology literature on fluency training, in which performances are maintained at high, accurate levels under progressively diminishing durations (Binder, 1996).

Overall, our findings demonstrate important effects of time constraints on emotion-based learning in the IGT when these constraints are targeted at the crucial decision-making phase, and also suggest that the reward/punishment schedules of the IGT are to some extent cognitively penetrable. The methodological features of the present study, such as the randomised positions of the good and bad decks and the use of subjective experience ratings and reaction time data, may be important considerations for future research in helping to identify the necessary and sufficient conditions for "unimpaired" IGT control group performance. This is clearly a central issue when investigating an aspect of executive function (emotion-based learning) that shows substantial variability across the population, and is increasingly understood to be important for the way in which humans make complex decisions in uncertain circumstances.

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