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Propensity for risk taking and trait impulsivity in the Iowa Gambling Task

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Abstract

The Iowa Gambling Task (IGT) is sensitive to decision making impairments in several clinical groups with frontal impairment. However the complexity of the IGT, particularly in terms of its learning requirements, makes it difficult to know whether disadvantageous (risky) selections in this task reflect deliberate risk taking or a failure to recognise risk. To determine whether propensity for risk taking contributes to IGT performance, we correlated IGT selections with a measure of propensity for risk taking from the Balloon Analogue Risk Task (BART), taking into account potential moderating effects of IGT learning requirements, and trait impulsivity, which is associated with learning difficulties. We found that IGT and BART performance were related, but only in the later stages of the IGT, and only in participants with low trait impulsivity. This finding suggests that IGT performance may reflect different underlying processes in individuals with low and high trait impulsivity. In individuals with low trait impulsivity, it appears that risky selections in the IGT reflect in part, propensity for risk seeking, but only after the development of explicit knowledge of IGT risks after a period of learning.

Keywords

Impulsivity; risk taking; decision making; Iowa Gambling Task (IGT); Balloon Analogue Risk Task (BART)

1. Introduction

The Iowa Gambling Task (IGT) is widely used to study decision making under risk and uncertainty and is a sensitive tool for detecting frontal dysfunction in several psychiatric populations (e.g. substance dependence, ADHD, pathological gambling) (e.g. Bechara & Damasio, 2002; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006; Malloy-Diniz, Fuentes, Leite, Correa, & Bechara, 2007; Stout, Busemeyer, Lin, Grant, & Bonson, 2004; Stout, Rock, Campbell, Busemeyer, & Finn, 2005). Although the IGT's sensitivity for detecting decision-making impairment is well established, recent studies have highlighted the complexity of this task and the challenges this poses for understanding what functions

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(or dysfunctions) it measures (Brand, Recknor, Grabenhorst, & Bechara, 2007; Buelow & Suhr, 2009; D.B. Dunn, Dalgleish, & Lawrence, 2006).

For example, the results of a recent study suggests that risk taking in the early and later stages of the IGT need to be considered separately (Brand, et al., 2007). This study found that a person's propensity for risk taking, as measured by the Game of Dice Task (where risks are explicit) (Brand, et al., 2005), was related to later IGT selections, but not earlier IGT selections. This suggests that in the earlier stages of the IGT, when players have little explicit knowledge about IGT alternatives, risk taking is not a deliberate act, but rather, reflects a failure to recognise risk. As the task progresses however, players presumably develop explicit knowledge of the risk profile across IGT alternatives. At this stage of the task, the player is able to express their propensity for risk taking, either by continued ‘risky’ choices (despite knowing risks), or by safer choice behaviour, which reveals their avoidance of risk.

In contrast to the IGT, where players cannot express their risk propensity until they have learned the risks, the Balloon Analogue Risk Task (BART) (Lejuez, et al., 2002) is designed so that players are able to express their risk propensity from the beginning of the task. This may account for why three previous studies have found no association between the tasks (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005; Bishara, et al., 2009; Lejuez, Aklin, Jones, et al., 2003), despite the fact that each task is separately related to drug abuse and other risk taking behaviours (Lejuez, Aklin, Jones, et al., 2003; Lejuez, Aklin, Zvolensky, & Pedulla, 2003; Stout, et al., 2004; Stout, et al., 2005). Perhaps if these studies had separated IGT selections into early (pre-learning) and later (post-learning) stages of the task, later IGT selections would have been associated with BART performance. For such a relationship to emerge however, a player's ability to learn IGT risks should be taken into account, especially since there is evidence of heterogeneity in the ability of some groups to learn about risk in decision making from their experience (Stout, et al., 2005).

Trait impulsivity, measured in its narrow form using questionnaires such as the Eysenck I_7 and Barratt Impulsiveness Scale[1], is associated with learning difficulties in problem solving situations (McMurran, Blair, & Egan, 2002) and increased risk taking in situations where learning is required (e.g. IGT) (Franken, van Strien, Nijs, & Muris, 2008;Sweitzer, Allen, & Kaut, 2008). This is important, because past studies that have attempted to link the IGT and BART have focussed on samples with high trait impulsivity such as substance abusers, who are known to have problems learning from experience about risk (Stout, et al., 2005). In an impulsive sample, inefficient learning in the IGT may mean that IGT performance, even in the later stages of the task, reflects unintentional risk taking rather than deliberate risk taking. Thus, it may be premature to conclude that IGT and BART are generally unrelated until the BART is compared to the most relevant stage of the IGT, and relevant individual differences such as impulsivity have been taken into account.

Thus, the aim of this study was to re-examine the association between IGT and BART, by correlating IGT and BART performance in early and later stages of the IGT separately. We also correlated IGT and BART performance from early and late stages of the IGT in groups with low and high trait impulsivity separately. We hypothesised that IGT and BART performance would be associated in the later stages of the IGT, but only in individuals with low trait impulsivity, reflecting their ability to learn IGT risks and therefore express their propensity for risk taking following a period of learning.

[1]These self-report questionnaires measure the tendency of individuals to consider negative consequences before acting (Miller, Joseph, & Tudway, 2004).

2. Method

2.1 Participants and procedure

Ninety eight young adults participated (52 females), ranging in age from 16 to 25 years (Table 1). We recruited participants from the local area surrounding Indiana University. Minor participants (<18) brought a consent form signed by a parent/guardian in addition to signing an assent form themselves. Inclusion criteria for participation were: 1) reporting no alcohol or substance use for at least 12 hours prior to the experiment, 2) reporting a regular night's sleep on the previous night (e.g. no night shift work), and 3) showing no signs of an extreme negative mood state, stress, or fatigue.

Participants completed a demographic questionnaire and a battery of personality, substance use, and computerised cognitive assessments. This study reports data from a subset of these measures described below.

2.2 Materials and participant characterisation

2.2.1 Impulsivity, IQ, and substance use—We assessed trait impulsivity using the 19 item Impulsiveness subscale from the Eysenck I_7 (Eysenck, Pearson, Easting, & Allsopp, 1985). Possible scores range from 0 to 19, with higher scores indicating higher impulsivity. The Impulsiveness subscale measures one component of a wider impulsivity construct sometimes referred to as rash impulsivity, or the tendency to act without considering negative consequences (Miller, et al., 2004). From the Eysenck I_7, we created two groups; one representing low-range impulsivity (lower 1/3 of distribution), and one representing high-range impulsivity (upper 1/3) in order to make it possible to determine whether trait impulsivity moderates the association between IGT and BART performance. Given the small sample size (and our expectation of a small effect size), we aimed to maximise the contrast between low and high impulsivity groups in order to increase our power to find an effect of impulsivity if it was present (Perales, Verdejo-Garcia, Moya, Lozano, & Perez-Garcia, 2009). The results of this work were not different when more extreme cut-off scores were used to create low and high impulsivity groups (upper and lower 1/4 and 1/5). The low impulsivity group (n=31, 16 females) had a mean impulsivity score of 2.5, which is lower than previous studies that have tested the association between IGT and BART behaviour (Aklin, et al., 2005; Bishara, et al., 2009; Lejuez, Aklin, Jones, et al., 2003). The high impulsivity group (n=30, 16 females) had a mean impulsivity score of 13.4, which is higher than the mean impulsivity score reported for high impulsivity groups in previous studies of decision-making (Sweitzer et al., 2008; Franken et al., 2008).

We used the Shipley Institute of Living Scale (Shipley, 1940) (total raw score stratified by age) to estimate WAIS-R full scale IQ (Zachary, Paulson, & Gorsuch, 1985). We also assessed the average weekly frequency of alcohol, tobacco, cannabis, and stimulant use (for the 12 months prior to testing) using a structured interview developed in our laboratory. Problems associated with alcohol use were assessed using the Michigan Alcohol Screening Test (MAST) (Selzer, 1971), and problems associated with illicit substance use were assessed using the Drug Abuse Screening Test (DAST) (Skinner, 1982).

The low impulsivity and high impulsivity groups were similar in age, $t(59) = 0.50$, $p = .62$ and gender, $\chi^2(1, N=61) = 0.89$, $p = .89$, but estimated IQ was lower in the high impulsivity group, $t(59) = 2.63$, $p = .01$ (Table 1). The high impulsivity group also used alcohol more frequently, $z = 2.47$, $p = .01$, and reported significantly more alcohol related problems on the MAST, $t(53)$ -3.19, $p < .01$. The high impulsivity group also used tobacco, $z = 3.05$, $p < .01$, cannabis, $z = 3.44$, $p < .01$, and stimulants, $z = 3.94$, $p < .01$ more frequently, and reported significantly more illicit substance use related problems on the DAST, $t(41) = -2.91$, $p < .01$.

2.2.2 Iowa Gambling Task (IGT) and Balloon Analogue Risk Task (BART)—In the IGT (Bechara, Damasio, Damasio, & Anderson, 1994) participants make a series of choices from a set of four computerised 'decks of cards' (decks A, B, C and D) with the aim of earning as much money as possible. Each deck is associated with a fixed immediate reward for every selection (A and B, $1.00; C and D, $0.50), as well as an occasional penalty which differs in frequency and magnitude across the decks. Although decks A and B have a larger fixed reward for each selection compared to decks C and D, selection of decks A and B is disadvantageous because the occasional losses associated with these decks (ranging from -$1.5 to -$12.50) mean that participants lose $2.50 per 10 selections. Selection of decks C and D on the other hand is advantageous because the occasional losses associated with these decks are relatively small (-$0.25 to -$2.50), resulting in a net gain of $2.50 per 10 selections. Players are not given any information about the decks and must learn from experience to select advantageously (see Ahn, Busemeyer, Wagenmakers, & Stout, 2008). Participants performed a single block of 150 trials, divided off-line into six blocks of 25 trials. Participants received any final earnings above the starting balance, and IGT performance was measured as the proportion of advantageous selections ((C+D choices)/ total choices).

In the BART (Lejuez, et al., 2002), participants 'inflate' a computerized image of a balloon by pressing a button to receive a small amount of money per pump (1 cent). The more participants inflate the balloon, the more money they receive. However, the balloon can explode at any time, resulting in a loss of potential earnings for that balloon. Therefore, participants who pump the balloon less times are typically regarded as being more risk-averse In this study, the point of explosion for each balloon was drawn from a random uniform distribution (without replacement) at the beginning of each trial (0 – 128 pumps). Therefore, the point at which the balloon would explode was unpredictable, and the probability that the balloon would explode increased with every pump. Participants performed 30 trials (balloons) and received any money earned from their performance. The outcome measure was the mean number of balloon pumps for unexploded balloons.

3. Results and discussion

3.1 IGT and BART performance

In the IGT, we found a main effect of block, with advantageous selections increasing as the task progressed, indicating that participants learned to avoid the risky decks, $F(5, 295) = 16.62$, $p < .001$, $\eta^2 = .22$. However, we found no between-subjects effect (impulsivity group), $F(1, 59) = 1.61$, $p = .21$, and no group by block interaction, $F(5, 295) = 0.80$, $p = .55$ (Figure 1a). Previous studies have reported differences between impulsive and non-impulsive groups in adult samples (Franken, et al., 2008; Sweitzer, et al., 2008). However, these differences are typically small, and we may have lacked statistical power to detect an effect. Furthermore, previous studies have found that individuals in the age group tested in this study (16-25 years) tend to make more disadvantageous choices in the IGT compared to adults (Overman, et al., 2004). In our sample, this could have resulted in a smaller range of IGT scores (skewed towards disadvantageous selections) compared to older groups, effectively reducing the degree of separation based on the impulsivity measure. Nevertheless, differences between groups in IGT performance are not necessary to demonstrate that the processes underlying task performance may differ between groups. Consistent with the findings of Vigil-Colet (2007), the low and high impulsivity groups made a similar number of BART balloon pumps, $F(1, 59) = 1.15$, $p = .29$ (Figure 1b).

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3.2 Association between IGT and BART performance in low and high impulsivity groups

IGT advantageous selections and BART pumps were not related in the whole sample, $r(98) = -.03$, $p = .77$, or in the high impulsivity group, $r(30) = -.04$, $p = .83$. However, a key observation in the low impulsivity group was that more IGT advantageous selections were associated with fewer BART pumps, $r(31) = -.36$, $p = .05$. This finding suggests that participants in the low impulsivity group who made more advantageous (low risk) selections on the IGT were also more risk averse on the BART.

In the IGT, players must experience wins and losses to learn which alternatives are risky (decks A and B). In the BART however, the risky alternative is obvious from the beginning of the task (pump balloon or collect money). Therefore, disadvantageous risky choices in the IGT may not have been related to BART pumps until participants had developed explicit knowledge of IGT risky decks through experience. Consistent with this idea, we found that BART pumps were significantly correlated with IGT advantageous selections in the later IGT blocks (blocks 4, 5, 6), but not in the earlier IGT blocks (Table 2). The correlations between BART pumps and IGT selections on blocks 4, 5, and 6 (with BART pumps) were significantly stronger than the correlation between BART pumps and IGT block 1 (trials 1-20) (but not IGT blocks 2 or 3) (all *p*s $<.05$), as determined by O. J. Dunn and Clarke's (1969) Z test for dependent correlations (see Hittner, May, & Silver, 2003). This pattern most likely has a similar basis to the findings reported by Brand et al. (2007), where Game of Dice Task performance (another measure of deliberate risk taking) was related to IGT risky choices only from the 40th trial onwards.

Unlike the low impulsivity group, IGT and BART performance were not correlated at any stage of the IGT in the high impulsivity group. This may simply reflect the fact that some participants in the high impulsivity group failed to develop explicit knowledge of risky IGT alternatives, which is consistent with past studies showing that impulsive individuals perform poorly in the IGT and other decision tasks that have a strong learning component (Franken, et al., 2008). We should note however, that although we did find evidence favouring an interpretation of deliberate risk taking in the IGT in the low impulsivity group (using the BART measure), the association between IGT and BART performance was not particularly strong. Thus, it is possible that some participants in the low impulsivity group also failed to learn the risky IGT alternatives.

One potentially important point is that impulsivity was narrowly defined in our study by the Impulsiveness Scale of the Eysenck I_7. A different picture may have emerged if another instrument was used to emphasise a different aspect of trait impulsivity. For example, sensation seeking, a personality characteristic linked to the impulsivity construct (Zuckerman, Eysenck, & Eysenck, 1978), is associated with a tendency for increased risk taking and impaired avoidance learning (Zuckerman & Kuhlman, 2000). Like individuals high in Eysenck Impulsiveness, sensation seekers appear to take more risks in the IGT (Buelow & Suhr, 2009); however it is not clear whether this is due to impaired learning of IGT payoff contingencies or increased risk seeking after the risky decks have been identified. If sensation seekers are more risk seeking in the IGT, then the association between IGT and BART performance may be strong in this group.

An important consideration in our sample, as is commonly observed, is that impulsivity was associated with other high risk characteristics such as substance use, thus creating a potential confound complicating the interpretation of the results. To examine the possibility that past substance use may also account for the lack of association between IGT and BART performance in the high impulsivity group, we computed a partial correlation analysis, taking into account past substance use. This analysis, which partialed out past substance use along with age and IQ, showed that the association between late IGT selections and BART pumps was still significant in the low impulsivity group, *pr*(31) = -.40, *p* = .045. Similarly, the finding in the high impulsivity group also remained unchanged, with no evidence of an association between late IGT selections and BART pumps, *pr*(30) = - .13, *p* = .54.

In conclusion, we found evidence for deliberate risk taking in the IGT, as determined by the association between IGT and BART performance. Importantly, our findings suggest that previous studies failed to find this association due to high levels of trait impulsivity in their samples, and because early and late IGT selections were combined into a single measure. These findings suggest that trait impulsivity is an important individual characteristic for understanding the determinants of disadvantageous risky choice in the IGT. Future studies should investigate different aspects of trait impulsivity to characterise this association further.

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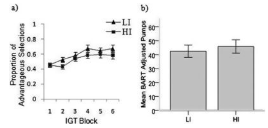

Figure 1.
(a) Mean proportion of IGT advantageous selections from block 1 to 6. (b) Mean number of BART pumps for unexploded balloons. Note: LI = low impulsivity group, HI = high impulsivity group. Error bars, +/-1 SE.

Table 1

Demographic and substance use variables for low and high impulsivity groups

	Impulsivity group			
	M(*SD*)		*Mdn (Min - Max)*	
	Low	**High**	**Low**	**High**
Age	20.35(2.52)	20.03(2.54)	21(16-25)	20(16-24)
IQ*	111(7.29)	105.67(8.53)	112(97-125)	105.67(87-123)
Eysenck I_7**	2.45(1.39)	13.37(2.16)	3(0-4)	13(11-18)
Alcohol *	1.59(1.73)	2.96(2.38)	1.08(0-6.62)	3.1(0-8)
Tobacco*	10.16(29.85)	30.45(43.95)	0(0-140)	3.95(0-175)
Cannabis**	0.69(2.27)	3.36(3.79)	0(0-10.5)	2(0-14)
Stimulants**	0.02(0.07)	0.25(0.46)	0(0-0.38)	0.05(0-1.9)

Note. Substance use is average weekly frequency for 12 months prior to testing. Significant differences at

* $p < .01$,

** $p < .001$.

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Table 2

Pearson's correlations between IGT and BART measures of task performance

	Low Impulsivity Group	High Impulsivity Group
IGT block 1	r(31) .003, p = .988	r(30) .070, p = .712
IGT block 2	r(31) -.186, p = .317	r(30) -.014, p = .940
IGT block 3	r(31) -.283, p = .123	r(30) .126, p = .508
IGT block 4	r(31) -.412, p = .021*	r(30) -.103, p = .588
IGT block 5	r(31) -.367, p = .042*	r(30) -.063, p = .739
IGT block 6	r(31) -.458, p = .010*	r(30) -.126, p = .508

Note. Two-tailed,

* $p < 0.05$