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ORIGINAL ARTICLE

Iowa Gambling Task in patients with early-onset Parkinson's disease: strategy analysis

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Abstract The aim of our study was to analyse decision making in early-onset Parkinson's disease (PD) patients performing the Iowa Gambling Task (IGT). We compared 19 patients with early-onset PD (≤45 years) on dopaminergic medication (no evidence of depression, dementia, executive dysfunction according to the Tower of London test and the Stroop test, or pathological gambling) with 20 age-matched controls. A computer version of the IGT was employed. The PD patients achieved slightly lower IGT scores than the control group. A detailed analysis based on 'shift frequencies' between the individual decks showed that the patients tended to change their preferences for the decks more frequently, with a higher preference for the 'disadvantageous' deck B. Control subjects seemed to develop a more effective strategy. These differences could be caused by the poorer ability of the patients to develop any strategy at all. We observed changes in decision making during IGT performance in patients with early-onset PD, although they had no executive dysfunction as measured by established neuropsychological tests. The more detailed analysis employed in the present study could lead to a more accurate study of IGT performance and application of IGT in clinical practice.

Keywords Parkinson's disease · Iowa Gambling Task · Decision making · Executive function

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Introduction

Considerable attention has recently been directed towards decision making in patients with Parkinson's disease (PD) [1, 2]. This interest is caused by a wide range of psychological symptoms observed in these patients [3]. For instance, a higher prevalence of pathological impulsive excessive and/or repetitive behaviour has been detected in patients with PD in comparison with the rest of the population [4–6]. Such behaviour is generally associated with a need for reward (be it a material gain or some pleasant experience) and can lead to negative consequences in the future, such as material losses and social handicap.

Decision-making processes and their disorders have been described by various theories and tested with several paradigms. One of the most frequently used measures associated with decision making is the Iowa Gambling Task (IGT) [7, 8]. The IGT was designed to simulate real-life decision making and has been tested on a range of participant groups for whom an impairment of these processes is presumed [9, 10]. As opposed to standard neuropsychological tests less sensitive or insensitive to VMPFC functioning, IGT seems to tap into its capacity

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reliably, and this makes the task unique [11]. IGT is predominantly used in research; however, it is possible to employ it in clinical practice as well [12–14].

Evaluation of IGT performance is a separate issue. The IGT score introduced in the first study is the traditional option [7]. It has been demonstrated that the IGT score has limitations which has led to a search for alternative and more detailed ways of assessment [9, 12, 15]. In order to describe other aspects of IGT performance than those offered by the IGT score, here we employed a detailed analysis based on shift frequencies between the decks in patients with early-onset PD on dopaminergic medication and to apply detailed analysis of IGT data. Although various studies with IGT have been conducted in a sample of patients with PD [12, 13], to our knowledge the subgroup of early-onset PD patients has been overlooked.

Materials and methods

We examined 19 early-onset PD patients (≤45 years) on dopaminergic medication (14 males, 5 females; mean age 50.3 ± 8.7 years) and 20 control subjects matched for age and sex (15 males, 5 females; mean age 50.0 ± 9.0 years) and without symptoms of PD or other brain impairment; see Table 1. Patients were recruited from the Brno Movement Disorders Centre database. They were diagnosed according to the United Kingdom Parkinson's Disease Brain Bank Criteria [16].

The average duration of PD was 11.3 ± 6.4 years. Patients were examined in ON-state (i.e. 2 h after last medication intake with absence of resting tremor and marked hypokinesia or rigidity). The average United Parkinson's Disease Rating Scale, part III (ON UPDRS III) score was 14.6 ± 8.7 [17]. The average Hoehn and Yahr Scale [18] score was 1.7 ± 0.57. Of the 19 patients, 18 were using a combination of L-DOPA (L-dihydroxyphenylalanine) and a dopamine agonist; one patient used a combination of L-DOPA and a catechol-O-methyltransferase inhibitor. The L-DOPA daily equivalent [19] was 1259 mg, SD 690.6.

Subjects with impaired executive function, severe depression, or a history of pathological gambling were excluded. Executive function was measured with the Tower of London test [20] (total correct standard score 96.5 ± 9.1; no patient had a total correct standard score lower than 80, the cut-off score for borderline executive function impairment), and the Stroop test [21] (Stroop interference T score 54.2 ± 7.2; only one patient was in the substandard range; none of the patients were in the impaired range). Participants with a score on the mini–mental state examination (MMSE) lower than 27 were excluded. None of the subjects had severe depression according to the Montgomery–Asberg Depression Rating Scale (MADRS) [22]. To assess gambling behaviour, the South Oaks Gambling Screen questionnaire was used, the cut-off score for exclusion was 1 (all included participants had a score of 0) [23]. In addition, none of the participants exhibited pathological gambling according to the modified Minnesota Impulse Disorders Interview [24]. Participants who did not perform the IGT correctly were also excluded (i.e. did not complete the task or had more than 10 % of choices outside the 3.5 s time limit).

Informed written consent was obtained from all participants; the study was approved by the Institutional Review Board of St. Anne's Hospital in Brno.

The analysis of the data was carried out with SPSS 15.0 and Statistica 8.0. The Kolmogorov–Smirnov Z test (K–S Z test) and Mann–Whitney U test (M–W U test) were employed for comparison of the groups ($\alpha = 0.05$). Spearman's correlation was used to associate the anamnestic patient data with IGT performance.

Results

We found a significant difference of total IGT score between the two groups ($m = -6.0 \pm 25.3$ in the PD

Table 1 Demographic and clinical data

	PD group	Control group
Amount of participants	19	20
Age (years)	50.32 (SD 8.74)	49.95 (SD 9.03)
Sex (male/female)	15/5	14/5
Working with computer (h/day)	1.4 (SD 2.79)	3.5 (SD 3.72)
Education (university/A levels/other)	2/6/11	5/2/13
Total score	−403.95 (SD 655.76)	33.75 (SD 905.40)
IGT score	−6.00 (SD 25.26)	10.30 (SD 29.42)
MMSE	29.37 (SD 0.96)	29.70 (SD 0.47)
Duration of PD (years)	11.32 (SD 6.42)	–
UPDRS III	14.58 (SD 8.71)	–
Hoehn and Yahr Scale score	1.68 (SD 0.58)	–

group; $m = 10.3 \pm 29.4$ in the control group) when using the Mann–Whitney U test ($U = 119$, $p = 0.048$). However, the Kolmogorov–Smirnov Z test recommended for small groups indicated a lack of statistical significance ($Z = 1.216$, $p = 0.061$) (Fig. 1).

We also analysed IGT scores during the task performance [25, 26]. At the beginning of the task, the choices tend to be random as the participants try to find the strategy [27–29]. However, in the second fifth of the task, the control group selected significantly more cards from 'advantageous' decks C and D ($m = -2.4 \pm 4.6$ in PD-group; $m = 1.3 \pm 8.2$ in control group); (M–W U test: $U = 114$, $p = 0.033$; K–S Z test: $Z = 1.208$, $p = 0.047$).

The average total score was somewhat lower in the patient group than in the control group, but the difference was found to be non-significant by both the M–W and K–S tests ($m = -404.0 \pm 655.8$ CZK in PD group; $m = 28.8 \pm 908.1$ CZK in control group); see Figs. 2, 3.

Analysis of the shifts

A comparison of the two groups showed 15 statistically significant differences (K–S exact test uncorrected for multiple comparisons); five of them remained significant after Tukey adjustment [30]; see Table 2. Our group of patients tended to shift their selections from disadvantageous to advantageous decks more often than the control group. This pattern was also noticeable after a monetary penalty. Nevertheless, the patients changed their preferences more frequently in the opposite direction (from advantageous to disadvantageous decks) as well. In contrast, the participants from the control group repeatedly selected cards from deck D (even after a monetary penalty). These results suggest different work styles or strategies. Whereas the selections of the control group were significantly more frequent for advantageous decks even though they had received a monetary penalty in the previous trial, the patients shifted their preferences for other decks, regardless of their characteristics.

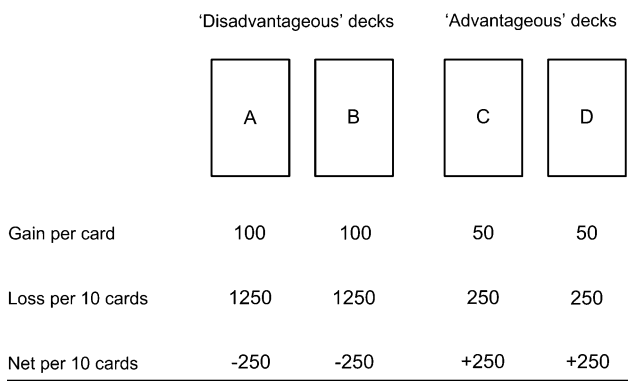

Fig. 1 A schematic diagram of the Iowa Gambling Task [8] modified

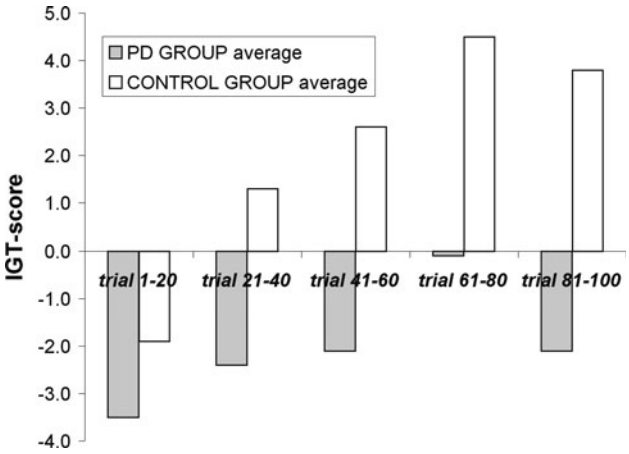

Fig. 2 IGT scores during the Iowa Gambling Task performance

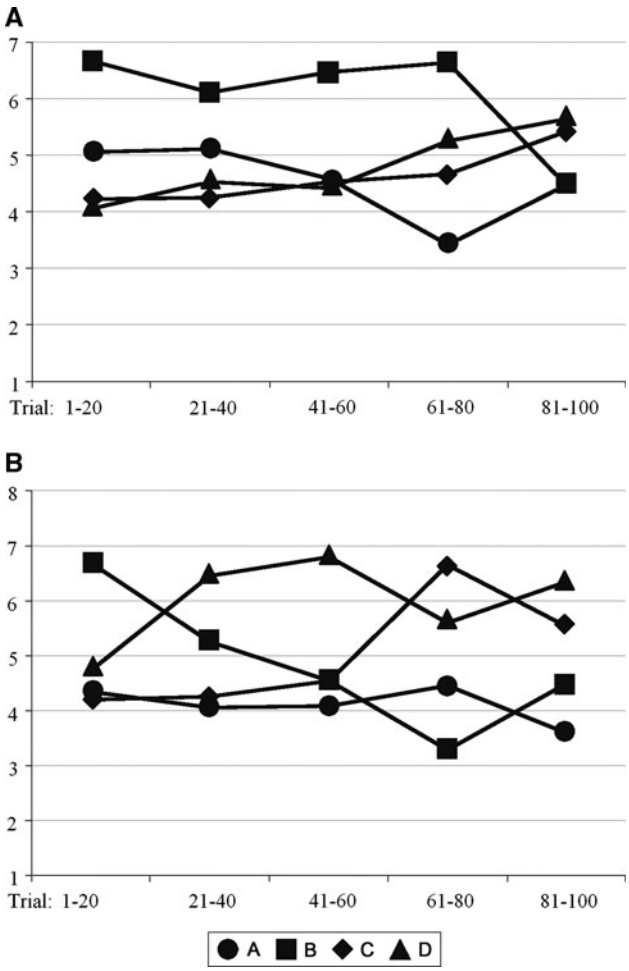

Fig. 3 The average sum of selections from individual decks during the performance of the Iowa Gambling Task. **a** PD group—average, **b** Control group—average

Furthermore, we analysed the data in terms of penalty frequency (seven significant differences were found). Both groups preferred to select cards from the decks with lower

penalty frequency (regardless of the amount). The patient group selected decks with higher winning values (deck B), while the control group appeared to opt for the advantageous deck with a lower penalty frequency (deck D). These findings might support suggestions about the importance of the experience of loss in decision making [28].

Results from many studies have revealed a preference for deck B ('prominent deck B' phenomenon); thus we also analysed the data from this point of view. At first sight, deck B appears to be the best choice because it offers larger gains and infrequent penalties [27]. Our results proved a stronger preference for deck B in the patient group; see Fig. 3; Table 2.

Subjective evaluation of the advantageousness/disadvantageousness of the decks revealed that the answers of the control group were more realistic in the view of long-term outcome (Mann–Whitney U test, significant difference: $U = 110$, $p = 0.023$; Kolmogorov–Smirnov Z test, insignificant). Significant differences between patients and controls with respect to subjective evaluation of advantageousness and disadvantageousness of individual decks are worth mentioning. In comparison with controls, patients labelled deck A as advantageous ($p < 0.05$) and decks C and D as disadvantageous ($p < 0.05$) more frequently. None of the control subjects considered deck D as a disadvantageous.

No significant correlation between IGT score and UPDRS-part III, severity of PD (Hoehn and Year stage), duration of PD, or L-DOPA equivalent was found. No correlation was found between IGT score and performance in established tests of executive function (e.g. Tower of London total correct standard score or Stroop interference T score).

Discussion

The most commonly used indicator of IGT performance—IGT score—has limitations. For instance, if a subject does

Table 2 Analysis of all variables that differed significantly: (Kolmogorov–Smirnov Z test; 5 % level of significance)

Variable	MdnP	sP	mP	MdnC	sC	mP	p
$IGT_{21–40}$	−2	4.65	−2.42	**2**	8.21	**1.30**	0.047
Shifts between decks generally							
sAC	**4**	1.65	**4.21**	2.5	3.55	3.50	0.033
sBC	**6**	2.66	**6.21**	4	4.06	5.05	0.044
sDD	5	4.64	5.74	**15**	12.01	**15.15**	0.001^{T}
Shifts after receiving penalty							
spAC	**3**	1.39	**2.84**	1	2.28	1.95	0.001^{T}
spDD	0	0.60	0.37	**2**	1.55	**1.75**	0.002^{T}
Shifts—advantageous/disadvantageous							
s_DaAd	**20**	5.79	**19.84**	16	9.76	16.15	0.015
s_AdDa	**19**	5.85	**19.74**	16	9.93	15.85	0.014
sp_DaAd	**6**	2.86	**5.95**	3	3.36	4.15	0.008
Sum of selections from deck							
deck B	**30**	8.39	**30.00**	21	10.20	24.05	0.024
Shifts—high/low frequency of penalties							
s_HfpHfp	19	6.25	19.37	**27**	10.44	**25.10**	0.047
s_LfpHfp	**26**	6.26	**25.84**	18	8.06	20.05	0.016
s_HfpLfp	**26**	6.32	**25.84**	17.5	7.95	20.20	0.005^{T}
s_LfpLfp	28	9.75	27.95	**35**	10.13	**33.65**	0.002^{T}
sp_HfpHfp	9	3.54	9.21	**14**	5.76	**12.80**	0.021
sp_LfpHfp	**3**	1.68	**3.16**	1.5	1.61	1.80	0.048
sp_HfpLfp	**14**	3.65	**13.21**	9	4.49	9.65	0.040
Evaluation of decks							
e_deck C_disadvant.		0.48	**0.32**		0.22	0.05	0.044
e_deck D_disadvant.		0.45	**0.26**		0	0	0.020

P PD group, *C* C group, *Mdn* median, *m* mean, *s* standard deviation, *p* *p* value; exact test without correction; superscript T–significance after Tukey correction for multiple comparisons [30], *$IGT_{21–40}$* IGT score in second fifth of the task, between 21st and 40th trial, *sAC* shift from deck A to deck C, *spAC* shift from deck A to deck C after receiving penalty, *s_DaAd* shift from disadvantageous deck to advantageous deck, *sp_DaAd* shift from disadvantageous to advantageous after penalty, *deck B* sum of selections from deck B, *s_HfpLfp* shift from the deck with high-frequency penalties to the deck with low-frequency penalties, *e_deckC_disadvant.* evaluation of deck C as disadvantageous

The bold values indicate statistical significance ($p < 0.05$)

not adopt any strategy and selects the decks randomly, IGT score should theoretically be close to zero. Performance evaluated on the basis of IGT score will be thus worse if a subject adopts a poor strategy in contrast to a situation where they do not adopt any strategy. IGT score does not express whether a player shifts between the decks A–B or C–D frequently, or if they clearly prefer one of them.

As a more detailed outcome, partial IGT score in blocks of 20 trials (i.e. individual fifths) is frequently reported [1, 2, 12, 27, 28]. In the first fifth of the IGT the subject acquires information for developing a strategy. In our study, as well as in others, there were no significant differences between PD patients and controls in IGT score by the 20th trial [1, 2]. Significant differences were found in the subsequent 20 trials ($IGT_{21–40}$), where controls but not patients achieved positive IGT scores. Deck choices became increasingly limited by the end of the task, because all the cards from certain decks had been already selected (each deck contains 40 cards) [22]. This led to a decrease of differences between the two groups as illustrated in Fig. 2. The amount of the cards available for selection from each deck in many studies is not limited; however, constituting a methodological difference in terms of comparisons between results. Therefore, the IGT score has the most significant value between the 21st and 80th trial.

An indisputable and clear benefit of total IGT score is that it summarizes and expresses performance in IGT by means of a single number. This necessarily means simplification. We consider an assessment of IGT performance more complicated and therefore requiring a more elaborate analysis. Detailed information, which in our opinion expresses strategy, can be better acquired via proposed analysis and interpretation of shifts between the decks.

By employing such an analysis it was demonstrated here that control subjects selected deck D significantly more frequently than patients in two subsequent trials (sDD), even after they received a penalty in the first of these trials (spDD). This is evidence for a clear preference of deck D and a demonstration of successful strategy at the same time—the subject is confident about the advantageousness of deck D and selects from it constantly (even after a monetary penalty). Shifts A–C and B–C (sAC and sBC) are noticeably more frequent in patients; especially indicative is shift A–C as a reaction to previous penalty (spAC). We consider this to be brought about by a poorer ability to develop a strategy in patients; their decision making seemed to be repeatedly a mere reaction to instantaneous win or loss. Therefore, long-term strategical reflection is missing and selections from the decks seem to be frequently random. If a subject assesses rationally basic instruction provided before the task [7], they should logically conclude that total gain will depend on the total amount of the cards selected from individual decks. Frequent shifting from deck to deck could be therefore interpreted as poor strategy. Frequent shifting of the decks in general is an indication of helplessness.

When evaluating shifts between advantageous and disadvantageous decks (sAdDa etc.) a tendency to shift from deck to deck in both directions can be observed in patients (e.g., sAdDa and sDaAd). Frequent shifting between selections from these two kinds of decks is further evidence of poor strategy.

If the decks are divided according to frequency of penalties (high in decks A and C and low in decks B and D), there is a trend towards shifting between these two kinds of decks in both directions in patients, after the received penalty as well as regardless of the penalty (sHfpLfp). In contrast, the control group showed a stronger tendency to continue selecting from a deck of the same kind, predominantly in decks with low frequency of penalties (sLfpLfp). Indeed, the difference between PD patients and healthy controls is most consistent and noticeable when analysing shifts between decks in terms of frequencies of penalties.

Subjective evaluation of individual decks after completing the game is other part of our study. Subjective evaluation was mainly associated with objective advantageousness and disadvantageousness of the decks. Although control subjects tended to select repeatedly from the decks with lower frequency of penalties (see above), they did not evaluate them as significantly more advantageous. This tendency was merely indicated and failed to reach significance. Furthermore, it is striking that no healthy control considered deck D disadvantageous in contrast to five patients who labelled it as such. One possible explanation is that low gains in decks C and D were not motivating enough for PD group in comparison with high instantaneous gains in decks A and B, thus the decks C and D appeared to be less profitable.

In our opinion, neither total nor partial IGT scores express all the details of strategy during the performance of IGT. The shifting scores brought the most interesting results. It seems to be a promising approach for future studies of IGT performance.

Poletti et al. [12] reviewed ten studies carried out on a sample of PD patients. While some of these studies report poorer IGT performance in patients [1, 2, 31], others found no significant differences in comparison with performance of healthy controls [32, 33]. Research studies also differ with regard to mean total IGT score achieved by their patient groups—negative as well as positive values are reported.

The results of our study are not as robust as those in studies that found distinctions between patients and healthy controls in IGT performance [1, 2, 12, 34]. None of these studies, however, focused on the specific group of early-

onset PD patients [12]. Moreover, the average duration of PD in our sample is slightly longer, but the average age of participants is considerably lower (by more than 10 and even as much as 20 years). Higher plasticity and more effective compensatory mechanisms are expected in younger patients and these aspects might have caused a lower contrast between both groups in our study. Ibarretxe-Bilbao et al. [14] found a difference in IGT score, when focusing on a subgroup of recently diagnosed PD patients (<5 years from the first manifestation of PD), but their average age was higher.

The 3.5-s time constraint for the card selection in IGT should also be mentioned. The average reaction times in the two groups did not differ, as would be expected if the performance of PD patients was biased due to the time constraint. According to the manual for the computerized version of IGT, task performance is resistant to the length of delay between trials [14]. However, it is possible that an explicit time scheme may have inhibited the participants; impulsivity might have been manifested more strongly if every participant had a chance to set their own pace. There was a slight difference between the two groups in the average time spent in front of the computer per day (PD patients about 1.4 h/day, controls about 3.5 h/day), yet no correlation with IGT score was found. Even though there were small distinctions in education level within the sample (see Table 1), we do not consider them because the duration of education did not differ significantly). Moreover, worse IGT performance has been reported recently in well-educated participants [35].

Another factor that might potentially influence IGT performance is depression. We found no correlation between MADRS score and IGT score in the PD group or in the control group.

We found no correlation between IGT performance (as measured by the IGT score) and executive function test performance (Tower of London test, Stroop test). Generally, only a small proportion of IGT studies on different populations found a statistically significant relationship between IGT performance and cognitive abilities. The majority of existing papers reported a nonsignificant relationship between the two, indicating that the considerable variability in IGT performance is not captured by current measures of executive functioning [10, 36]. Intact functioning of VMPFC seems to be important for successful IGT performance and the aforementioned neuropsychological tests are generally insensitive to this area; standard tests of executive functions examine different areas, mainly the dorsolateral prefrontal cortex [1, 10, 12, 37, 38]. An issue of valid assessment of the VMPFC function is at present of interest for many neuropsychologists because there is no single standardized test of dysfunction of this region [11]. The detailed analysis of IGT performance employed in this study could be applied successfully in the clinical setting, providing clinicians with an early indication of possible decline in cognitive abilities and thus offering an opportunity for intervention before the cognitive or behavioural problems manifest fully.

Conclusion

Our results suggest certain differences in decision making between a group of patients with early-onset PD and a control group even though no deficit in executive function was detected. PD group did not perform IGT significantly more poorly than the control group in terms of IGT score or total winning; however, they showed a stronger tendency to switch between the decks in general. PD group struggled to find any strategy at all. Our results demonstrate the usefulness of a more detailed analysis of IGT performance. The most frequently used indicators of success, such as IGT scores, have certain limitations. More subtle distinctions between the strategies of the two groups were detected by means of an alternative analysis. We suggest that this approach to IGT data could be a promising method for the future study of IGT performance, as well as in clinical practice [12].

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Ethical standards The study has been approved by appropriate ethics committee and has therefore been performed in accordance with ethical standards laid down in the 1964 declaration of Helsinki.

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