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Decision-making impairments in patients with pathological gambling

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Abstract

Pathological gambling (PG) is most likely associated with functional brain changes as well as neuropsychological and personality alterations. Recent research with the Iowa Gambling Task suggests decision-making impairments in PG. These deficits are usually attributed to disturbances in feedback processing and associated functional alterations of the orbitofrontal cortex. However, previous studies with other clinical populations found relations between executive (dorsolateral prefrontal) functions and decision-making using a task with explicit rules for gains and losses, the Game of Dice Task. In the present study, we assessed 25 male PG patients and 25 male healthy controls with the Game of Dice Task. PG patients showed pronounced deficits in the Game of Dice Task, and the frequency of risky decisions was correlated with executive functions and feedback processing. Therefore, risky decisions of PG patients might be influenced by both dorsolateral prefrontal and orbitofrontal cortex dysfunctions.

Keywords: Risk-taking behavior; Executive functions; Dorsolateral prefrontal cortex; Orbitofrontal cortex; Gambling task

1. Introduction

One of the most common problems of everyday life of patients with pathological gambling (PG) is uncontrolled and excessive financial risk-taking behavior leading to financial and social troubles. However, the underlying processes of risky decisions in PG are still unresolved. So far, only a few investigations have directly addressed neuropsychological correlates of decision-making and associated functions in PG. In this context, some studies suggest attentional and executive dysfunctions in PG patients (e.g. Rugle and Melamed, 1993; Specker et al., 1995). Cavedini et al. (2002b) administered a laboratory test assessing decision-making under ambiguous conditions (the Iowa Gambling Task; Bechara et al., 1994) in PG and found

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deficits in their sample. This task requires participants to choose between four different alternatives, each of which is associated with different gains and losses. Subjects have to learn to make advantageous decisions without having explicit knowledge about the rules of the game from the beginning of the task. Several studies employing this task revealed decision-making deficits in a wide range of neurological or psychiatric patients, such as patients with orbitofrontal/ventromedial prefrontal cortex lesions (Bechara et al., 1998; Bechara et al., 2000; Manes et al., 2002; Fellows and Farah, 2005), patients with frontal lobe dysfunctions due to substance addiction (Bechara et al., 2001; Bechara and Damasio, 2002; Bechara et al., 2002; Bechara and Martin, 2004), patients with Parkinson's and Huntington's disease (Stout et al., 2001; Thiel et al., 2003), schizophrenia (e.g. Whitney et al., 2004), obsessive-compulsive disorder (Cavedini et al., 2002a) or anorexia nervosa (Cavedini et al., 2004). The PG sample of Cavedini et al. (2002b) showed highly similar decision-making impairments compared with those of frontal lobe damaged patients. They further described a dissociation of poor Iowa Gambling Task performance from intact executive functions as assessed with the Wisconsin Card Sorting Test (WCST).

However, executive functions might have a substantial impact on decision-making processes if rules for reinforcement and punishment were explicitly told to the subjects and the outcome was defined by probabilities. Previously, we have shown that in a gambling task with explicit rules, the Game of Dice Task, decision-making is strongly related to executive functions measured with the WCST, i.e., in patients with Korsakoff's syndrome (Brand et al., 2005a) or with Parkinson's disease (Brand et al., 2005b). In the present study, we examined decision-making abilities of PG patients in a gambling task with explicit rules and predicted that deficits in this task would be correlated with performance in executive tasks.

2. Participants and methods

2.1. Participants

Twenty-five male patients with pathological gambling (PG) according to ICD-10 (World Health Organization, 1994) and DSM-IV (American Psychiatric Association, 1994) criteria and 25 male healthy controls (CG) without neurological or psychiatric history participated in the study. The PG patients were recruited from the Sociopsychosomatic Clinic Wigbertshöhe, Germany. All patients underwent an extensive neurological and psychiatric examination carried out by the physicians of the cooperating clinic. Mean duration of illness was 12.9 (S.D.=6.7) years, mean duration of current stationary therapy was 7.5 (3.5) weeks at examination time. None of the patients or the control subjects had the diagnosis of alcoholism or other substance dependence except for nicotine. Most (21) patients and a comparable number of the control subjects (19) were nicotine smokers (cigarettes). All patients regularly consumed caffeine. Three patients had mild depression (not diagnosed as DSM-IV axis I diagnosis) and were treated with antidepressant medication (one patient with tricyclic antidepresssants and two patients with selective serotonin reuptake inhibitors). In both groups, participants with further (current or preceding) neurological or psychiatric symptoms were excluded from the study. Before examination, all participants were informed about the procedure of the study and gave written consent. The groups were well matched regarding age, education and intelligence (measured using the German intelligence test battery *Leistungs-Prüfsystem*, LPS (Sturm et al., 1993) (see Table 1). All patients and controls were right-handed.

2.2. Methods

2.2.1. Neuropsychological and personality assessment

A neuropsychological test battery comprising tests for main cognitive functions was administered to the patients (see Table 2). The Modified Card Sorting Test (MCST, Nelson, 1976; norms of Lineweaver et al., 1999) was used to measure categorization, set-shifting and tendency to perseverate as well as the ability to utilize feedback (see Spreen and Strauss, 1998). Interference susceptibility was assessed with the 'Interference Trial' of the Word Color Interference Test according to the Stroop paradigm (*Farbe-Wort-Interferenz-Test*, FWIT, Bäumler, 1985). To study speed of information processing, the 'Word Trial' and the 'Color Trial' of the Word Color Interference Test were used (speed of reading and color naming). The

Table 1
Age, education and intelligence of the PG patients and the control group (CG)

	PG	CG	*T*	*df*	*P*
	n=25	*n*=25			
Mean age in years (S.D.)	40.08 (10.12)	40.68 (11.66)	−0.194	48	0.847
Mean education in years (S.D.)	9.56 (0.71)	9.64 (0.70)	−0.401	48	0.690
Mean intelligence, LPS (S.D.)	109.17 (11.81)	108.71 (13.48)	0.128	48	0.898

LPS=Leistungs-Prüfsystem. S.D.=standard deviation.

general cognitive state was screened by the DemTect (Kessler et al., 2000) consisting of five subtests: word list immediate recall (testing verbal short-term memory), number transcoding (number processing and set-shifting), supermarket task (categorical verbal fluency), digit span reverse (working memory) and word list delayed recall (verbal long-term memory). The scores of the five subtests can be summarized to a total score (0–18) following an age correction of the raw scores.

Sensation seeking was examined with an adapted version of the Sensation Seeking Scale V (SSS-V) of Zuckerman et al. (1964) comprising four different dimensions of sensation seeking (total 40 items, each dimension having 10): *thrill and adventure seeking* (TAS), *experience seeking* (ES), *disinhibition* (DIS) and *boredom susceptibility* (BS). The items were adapted for the German population with minimal changes from the original version.

Personality was assessed with the Freiburg Personality Inventory Revised (*Freiburger Persönlichkeits Inventar revidiert*, FPI-R, Fahrenberg et al., 2001), examining 12 different facets of personality: *life satisfaction, social orientation, achievement motivation, inhibition, excitability, aggressiveness, stress, physical complaints, worries about health, openness, extraversion and neuroticism.* Furthermore, we administered the *neuroticism* scale of the NEO

Table 2
Results in the neuropsychological test battery of the PG patients and the control group (CG)

		Max	PG		CG	
			Mean	S.D.[a]	Mean	S.D.[a]
DemTect	Word list immediate	20	13.16	(2.37)	13.40[b]	(3.06)[b]
	Number transcoding	4	3.68	(0.63)	3.74[b]	(0.58)[b]
	Supermarket task	30	23.36	(6.23)	24.28[b]	(5.49)[b]
	Digit span reversed	6	4.60	(0.76)	4.71[b]	(1.08)[b]
	Word list delayed	10	5.28	(2.07)	7.02[b]	(2.01)[b]
	Total (transformed)	18	14.15	(3.52)	15.39[b]	(2.83)[b]
FWIT	Words	sec.	32.21	(4.49)	31[b]	(T=50)[b]
	Colors	sec.	45.58	(8.84)	49[b]	(T=50)[b]
	Interference	sec.	81.71	(18.58)	90[b]	(T=50)[b]
	Interference-colors		36.04	(14.27)	41[b]	(T=50)[b]
MCST	Correct	48	38.48	(7.01)	na[c]	
	Non-perseverative errors	–	7.52	(4.89)	2.94[b]	(5.96)[b]
	Perseverative errors	–	1.00[d]	(0–11)[e]	1.50[b]	(4.07)[b]

FWIT=Farbe-Wort-Interferenz-Test (Word Color Interference Test).
MCST=Modified Card Sorting Test (norms from Lineweaver et al., 1999).
LPS=Leistungs-Prüfsystem.
[a] S.D.=standard deviation.
[b] Scores of norm group.
[c] na=not available.
[d] Median.
[e] Range.

Personality Inventory Revised (*NEO-Persönlichkeitsinventar revidiert*, NEO-PI-R, Ostendorf and Angleitner, 2003) including the subscale *impulsivity*.

Control subjects were examined with a reduced test battery including the experimental task of risk-taking behavior and neuropsychological tests for intelligence and general cognitive abilities. For the evaluation of possible cognitive impairments or personality deviations from normal values of the PG patients, scores of the standardized tests' norm groups were used (see Tables 2 and 3).

2.2.2. Decision-making under risk

To examine risky decisions in a gambling situation the computerized Game of Dice Task (see Brand et al., 2005a) was used. In the Game of Dice Task, subjects are asked to maximize their fictive starting capital of 1000€ within 18 dice throws. One virtual single dice and a shaker are used. In each trial, subjects have to guess which number will occur in the next throw. They can choose between the different single numbers or a combination of two numbers, three numbers or four numbers. Each choice is associated with specific fictive gains and losses depending on the probability of occurrence of choice: 1000€ gain/loss for the choice of a single number (winning probability 1:6), 500€ gain/loss for two numbers (winning probability of 2:6), 200€ gain/loss for three numbers (winning probability 3:6) and 100€ gain/loss for four numbers (winning probability 4:6) (see Fig. 1A). Thus, the winning probabilities can be reasoned easily, and the amount of risk associated with each choice is obvious. Thereafter, the dice is thrown and the current winning number is presented. Participants receive feedback (gain or loss) for their previous decision in a visual and acoustic way and the changed capital is shown

Table 3
Results in the questionnaires of the PG patients and the control group (CG)

		Max	PG		CG		
			Mean	S.D.[a]	Mean	S.D.[a]	
SSS-V	Thrill and adventure seeking	10	5.46	(2.95)	6.44	(2.70)	ns[b]
	Experience seeking	10	4.75	(1.75)	5.11	(2.57)	ns[b]
	Disinhibition	10	4.38	(2.45)	5.11	(1.45)	ns[b]
	Boredom susceptibility	10	4.21	(2.04)	3.89	(2.15)	ns[b]
	Total	40	18.88	(5.86)	20.56	(5.15)	ns[b]
FPI-R	Life satisfaction	9[c]	3.00[d]	(1–6)[e]	4–6[f]		na[g]
	Social orientation	9[c]	5.00[d]	(1–9)[e]	4–6[f]		
	Achievement motivation	9[c]	4.50[d]	(2–9)[e]	4–6[f]		
	Inhibition	9[c]	6.00[d]	(3–9)[e]	4–6[f]		
	Excitability	9[c]	7.00[d]	(2–9)[e]	4–6[f]		
	Aggressiveness	9[c]	5.00[d]	(1–9)[e]	4–6[f]		
	Stress	9[c]	6.00[d]	(3–9)[e]	4–6[f]		
	Physical complaints	9[c]	6.00[d]	(1–9)[e]	4–6[f]		
	Worries about health	9[c]	5.00[d]	(1–6)[e]	4–6[f]		
	Openness	9[c]	6.00[d]	(5–9)[e]	4–6[f]		
	Extraversion	9[c]	4.00[d]	(1–7)[e]	4–6[f]		
	Neuroticism	9[c]	7.00[d]	(2–9)[e]	4–6[f]		
NEO-PI-R	Neuroticism	T[h]	59.39	(10.04)	na[g]		

SSS-V=Sensation Seeking Scale version V.
FPI-R=Freiburg Personality Inventory Revised.
NEO-PI-R=NEO Personality Inventory Revised.
[a] S.D.=standard deviation.
[b] ns=not significant (P>0.05).
[c] Stanines (standard scores ranging from 1 to 9).
[d] Median.
[e] Range.
[f] Range of 4–6=54% of norm group.
[g] na=not administered.
[h] *T*-scores between 40 and 60 represent scores within the range of one standard deviation of the norm group's scores.

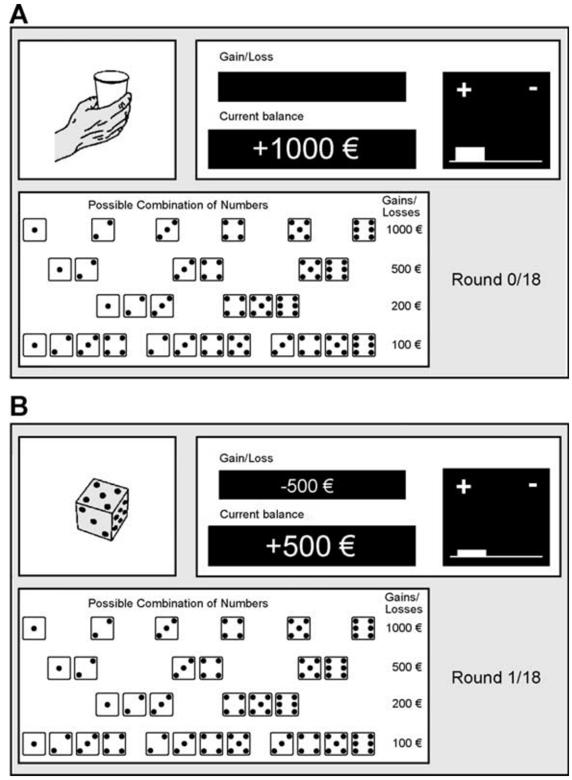

Fig. 1. The Game of Dice Task: (A) shows the window by start of the task. Before each trial, subjects have to decide between a single number (e.g. '5') or a combination of two numbers (e.g. '4' and '5'), three numbers (e.g. '4', '5' and '6') or four numbers (e.g. '3', '4', '5' and '6'). Thereafter, the dice are tossed (animated on the screen) and the result is presented (B). At the same time, an acoustic signal indicates if the throw was successful or not and the gain or loss is shown. Furthermore, the capital changes depending on the received gain or loss which is shown immediately (figure modified from Brand et al., 2005a).

(see Fig. 1B). The maximum final balance can be 19,000€ (if the subject chooses a single number and is successful each throw). The maximum negative balance can be −17,000€ (if the subject chooses a single number and is unsuccessful in each throw). To analyze different decisions, we differentiate between long-term 'disadvantageous decisions' (the choices of one or two numbers with winning probability less than 50% and high gains but also high penalties) and long-term 'not disadvantageous decisions' (the choices of three and four numbers with winning probability of 50% or higher associated with low gains but also low penalties) (see also Brand et al., 2005a).

For ethical reasons, neither the PG patients nor the control subjects received financial compensation for their participation in the study. All participants were briefed that the goal of the game was to gain as much fictitious money as possible as if it were their own money. To make sure that subjects completely understood the rules of the game, they were asked to repeat the most important parts of the rules (i.e. they were asked to give an example for gain/loss associated with a specific alternative) before starting the task.

3. Results

Results from the neuropsychological test battery are shown in Table 2. The general cognitive state (DemTect total score transformed) of the PG patient group as well as all other neuropsychological functions were unimpaired.

The groups did not differ in the total score and in the subscales of the SSS-V. In the personality inventory (FPI-R), the patient group showed a normal profile except for the subscales *life satisfaction* (which was lower than average), *excitability* (higher than average) and *neuroticism* (also higher than average) (see Table 3).

In the Game of Dice Task, the patients showed a significant preference for the disadvantageous choices compared with the healthy subjects (PG: median=10.0, range=1–18; CG: median=2.0, range=0–13; U=101.00, P<0.001, Mann–Whitney U-test). Accordingly, the final balance of the PG patients was significantly lower than that of the controls (PG: median=−1700€, range=−13,000€ to +1700€; CG: median=+900€, range=−6900€ to +1700€; U=112.00, P=0.002, Mann–Whitney U-test).

Additionally, we analyzed how often each single alternative was chosen by the patients compared to the controls. A multivariate analysis of variance with zrepeated measurements with 'choice' as the within-subject factor and 'group' as the between-subject factor revealed a significant overall effect (F=12.21, df=3, P<0.001) and a significant interaction 'choice'×'group' (F=10.11, df=3, P<0.001). All single comparisons (t-tests for single alternatives) between the groups were highly significant: one number: t=2.53, df=30.59, P=0.015; two numbers: t=4.35, df=36.80, P<0.001; three numbers: t=−2.79, *df*=40.56, *P*=0.007; four numbers: *t*=−2.88, *df*=48, *P*=0.006. Fig. 2 demonstrates these differences.

Game of Dice Task performance in the PG group was correlated with categorization, cognitive flexibility, and set-shifting (assessed by the MCST) as well as interference susceptibility (interference score of the FWIT). All other neuropsychological functions were not correlated with Game of Dice Task performance (see Table 4).

The assessed personality variables such as sensation seeking (SSS-V), or the subscales of the FPI-R and the *neuroticism* scale of the NEO-PI-R were not correlated with the frequency of disadvantageous choices in the Game of Dice Task (all *P*'s>0.05). We did not find influences of age, years of education, duration of illness, current therapy and nicotine consumption (all *P*'s>0.05). In the control group, GDT performance was also unrelated to age, education, intelligence and SSS-V (all *P*'s>0.05).

To analyze feedback processing, the use of negative feedback for the next decision was determined if subjects had chosen a disadvantageous alternative and received a negative feedback (loss of 500 or 1000) in a previous trial, and then chose a not disadvantageous alternative in the next trial. According to this procedure, we excluded subjects who did not make at least one disadvantageous choice during the entire task duration as well as those who never received negative feedback following a disadvantageous decision. The feedback analyses therefore included 22 PG patients and 8 control subjects. PG patients used negative feedback only in 33.04% of incidences, whereas control subjects used 75.28% of their negative feedback to choose a not disadvantageous alternative in the next trial. A statistical analysis of this difference is problematic since only 8 control participants and 22 patients could be included in the analysis. Nonetheless, the obtained difference was significant (*t*=−3.09, *df*=28, *P*=0.004, *t*-test). In the PG group, the use of negative feedback was negatively correlated with frequency of disadvantageous decisions in the Game of Dice Task (*R*=−0.492, *P*=0.020) but not to performance in the MCST (correct: *R*=−0.065, *P*=0.775; non-perseverative errors: *R*=0.115, *P*=0.610; perseverative errors: *R*=−0.040, *P*=0.860) or any other neuropsychological or personality variable.

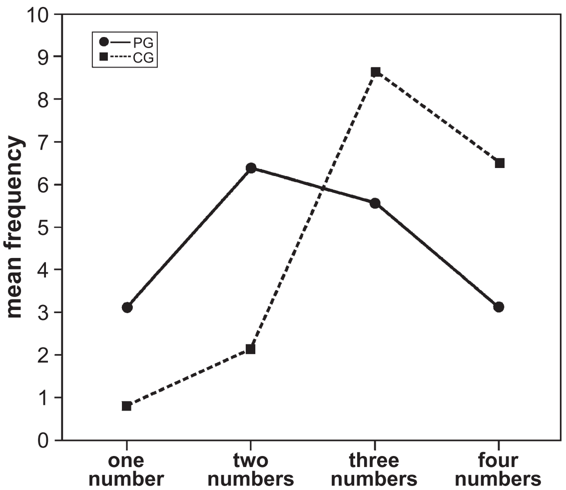

Fig. 2. Mean frequency of each single alternative chosen by the PG group and the controls (CG).

Table 4
Correlations in the PG group (*n*=25) between the frequency of disadvantageous decisions in the Game of Dice Task and neuropsychological task performance

		R	*P*
DemTect	Word list immediate	−0.257	ns[a]
	Number transcoding	0.121	ns[a]
	Supermarket task	−0.191	ns[a]
	Digit span reversed	−0.295	ns[a]
	Word list delayed	−0.238	ns[a]
	Total (transformed)	−0.388	ns[a]
FWIT	Words	−0.063	ns[a]
	Colors	0.025	ns[a]
	Interference	0.331	ns[a]
	Interference-colors	0.415	0.040
MCST	Correct	−0.515	0.009
	Non-perseverative errors	0.499	0.011
	Perseverative errors	0.501 (Rho[b])	0.011
LPS		−0.260	ns[a]

FWIT=Farbe-Wort-Interferenz-Test (Word Color Interference Test).
MCST=Modified Card Sorting Test.
LPS=Leistungs-Prüfsystem.
[a] ns=not significant (*P*>0.05).
[b] Rho=non-parametric correlation (Spearman) due to deviation from normal distribution of this variable.

4. Discussion

PG patients are impaired in decision-making in a risk situation with explicit and stable rules for gains and losses. Though the PG group's performances in the examined neuropsychological domains were within the normal range, the frequency of disadvantageous decisions in the Game of Dice Task was highly correlated only with specific executive functions such as categorization, cognitive flexibility, set-shifting and interference susceptibility, but not with personality traits. Negative feedback following a disadvantageous decision was scarcely used by the PG patients compared with controls and was associated with disadvantageous decisions in the Game of Dice Task.

Our findings of impaired decision-making in PG patients are in line with previous results, especially those of Cavedini et al. (2002b). A possible explanation of these results is a dysfunctional orbitofrontal cortex in PG (cf. Cavedini et al., 2002b). The orbitofrontal/ventromedial prefrontal cortex is supposed to mediate the use of feedbacks for current decisions (cf. the Somatic Marker Theory of Damasio, 1996). Our correlation between feedback use and Game of Dice Task performance confirms this hypothesis of altered orbitofrontal/ventromdedial changes in PG. Additionally, we suggest that specific executive functions also play an important role in risky decisions in PG patients and therefore in maintenance of PG. Evidence for this reasoning can be derived from the strong correlations between several measures of the MCST and Game of Dice Task performance in our PG patients, who were on average not even clinically impaired in the MCST.

The correlation between executive functions and decision-making is in contrast to a number of previous studies (e.g. Bechara et al., 1998; Bechara et al., 2000; Bechara et al., 2001; Bechara and Damasio, 2002; Cavedini et al., 2002a; Cavedini et al., 2002b; Tranel et al., 2002; Apkarian et al., 2004; Bechara and Martin, 2004; Cavedini et al., 2004; Ritter et al., 2004; Rotheram-Fuller et al., 2004; Whitney et al., 2004), which mostly found weak associations of decision-making and executive functions (usually measured with the WCST or modified versions). However, a plausible explanation for these divergent findings may be that in the Iowa Gambling Task decisions are first made under conditions of ambiguity since the rules for gains and losses and winning probabilities are unclear and have to be learned by the participants while performing the task. In this case, the efficient use of executive control functions is likely less critical for success than appropriate emotional feedback processing. The finding that executive functions are correlated with Game of Dice Task performance in our PG sample is in accordance with previous clinical studies in Korsakoff's and Parkinson's patients. Their Game of Dice Task deficits were related to lowered MCST performance (Brand et al., 2005a; Brand et al., 2005b).

Kim and Grant (2001) showed that PG was associated with higher novelty seeking, in contrast to our result of no differences in the SSS-V between PG patients and controls. One reason for that might be the use of different methods: Kim and Grant used the 'novelty seeking' subscale of the Tridimensional Personality Questionnaire (Cloninger, 1987), which differs from the SSS-V and therefore results of the two studies are not directly comparable. Nevertheless, in our PG sample the subscales 'excitability' and 'neuroticism' of the FPI-R were elevated from normal average. This points to an association of PG and impulsiveness/extravagance resembling the results of Kim and Grant (2001), without however being directly related to Game of Dice Task performance.

Though we did not investigate any direct indicators of possible brain pathology or neurobiological alterations in pathological gamblers, frontal lobe dysfunctions involving dorsolateral prefrontal cortex functions in addition to orbitofrontal dysfunctions are likely for our patients. Thus, in PG patients, two possible underlying mechanisms may influence risk-taking behavior in an explicit gambling task: (1) alterations of orbitofrontal/ventromedial prefrontal cortex functions (cf. Cavedini et al., 2002b) as well as changes in limbic and paralimbic activity (Potenza et al., 2003). These might result in uncontrolled behavior and gambling urges as well as in disturbances of feedback processing. This interpretation is also in accordance with previous studies showing poor Iowa Gambling Task performance in other clinical populations, such as substance-addicted subjects or patients with obsessive-compulsive disorder or anorexia nervosa (e.g. Bechara, 2001; Bechara et al., 2001; Cavedini et al., 2002a; Cavedini et al., 2004) or in healthy children (Crone and van der Molen, 2004). (2) Changes of the dorsolateral prefrontal cortex leading to impairments of planning capacity and the generation and use of cognitive strategies can also result in disadvantageous decisions in accordance with previous studies using the Game of Dice Task as a gambling task with explicit rules (Brand et al., 2005a; Brand et al., 2005b).

Further studies might assess PG patients with both decision-making tasks with explicit (e.g. the Game of Dice Task) and implicit rules (e.g. the Iowa Gambling Task), to show whether the different types of decisions share common neuropsychological functions in PG.

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