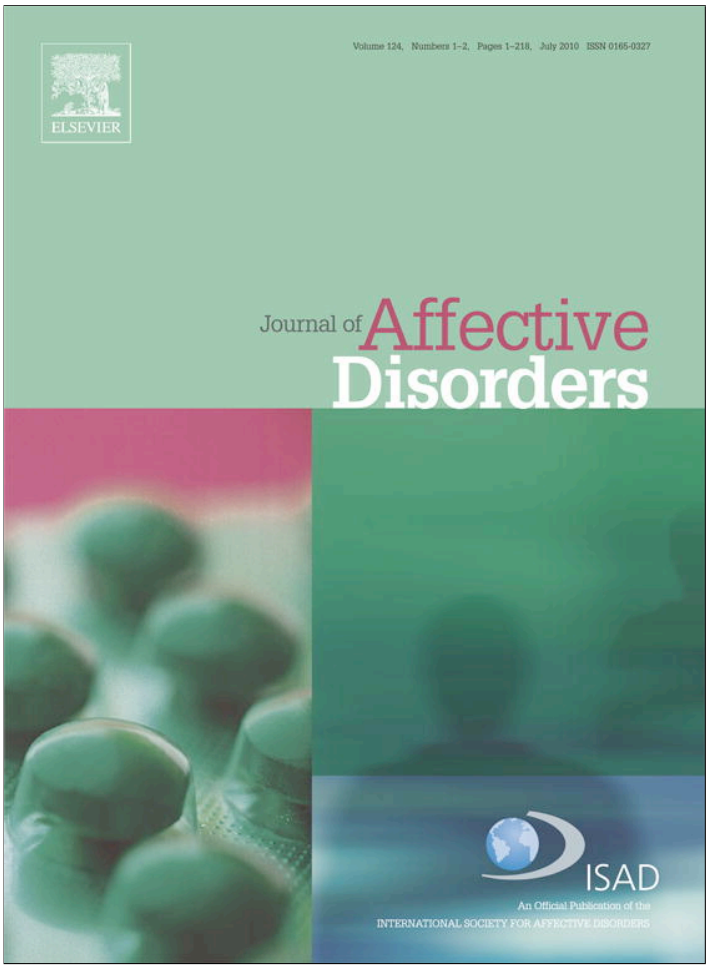

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Brief report

Impaired flexible decision-making in major depressive disorder

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ABSTRACT

Background: Depression is associated with dysfunctional affective states, neuropsychological impairment and altered sensitivity to reward and punishment. These impairments can influence complex decision-making in changing environments.
Methods: The contingency shifting variant Iowa Gambling Task (IGT) was used to assess flexible decision-making performance in a group of medicated unipolar Major Depressive Disorder (MDD) patients ($n=19$) and a group of healthy control volunteers ($n=20$). The task comprised the standard IGT followed by a contingency-shift phase where decks progressively changed reward and punishment schedule.
Results: Patients with MDD showed impaired performance compared to controls during both the standard and the contingency-shift phases of the IGT. Analysis of the contingency-shift phase demonstrated that individuals with depression had difficulties perceiving when a previously bad contingency became good.
Limitations: The present findings have several limitations including small sample size, the possible confounding role of medication and absence of other neuropsychological tests (i.e., executive function).
Conclusion: Depressed patients show impaired decision-making behaviour in static and dynamic environments. Altered sensitivity to reward and punishment is proposed as the mechanism responsible for the lack of advantageous choices and poor adjustment to a changing environment.

1. Introduction

An altered sensitivity to reward and punishment has been advanced as an essential aspect in the maintenance of depressive symptoms such as diminished motivation and impaired decision-making ability (Martin-Soelch, 2009). Elliott et al. (1996) showed that depressed patients have an enhanced sensitivity to negative feedback and are highly influenced by punishing stimuli. Similarly, Steffens et al. (2001) showed that depressed patients are more likely to commit errors in trials followed by negative feedback (see also Santesso et al., 2008; Nestler and Carlezon, 2006).

The study of sensitivity to reward and punishment in depression has been conducted using several paradigms. A number of neuropsychological studies have opted to use the Iowa Gambling Task (IGT; Bechara et al., 1994). The original version of 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 and/or loss. All decks lead to immediate gain, but vary in the frequency of loss. Two of the decks result in frequent immediate high gain per choice, but produce regular losses, leading to a cumulative long-term loss. The remaining two decks typically result in lower immediate rewards, but also generate fewer losses, resulting in a cumulative long-term gain. The limited number of previous studies employing the IGT with depressed

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patients has found mixed and inconclusive results, with one study showing impaired learning (Must et al., 2006), another showing similar performance between depressed and control participants (Dalgleish et al., 2004), and a more recent study showing that patients outperform controls (Smoski et al., 2008).

Flexibility and adaptability to changing contingencies are essential for successful behaviour, yet sub-optimal flexibility and set-shifting impairments have been observed in a range of disorders (e.g., Withall et al., 2010; Wobrock et al., 2008). Studies investigating sensitivity to reward and punishment in depression have mostly focussed on behavioural tasks where the reinforcement contingencies remain unchanged across trials. Despite being initially faced by uncertainty, participants playing the IGT are not required to adjust their learning to novel environmental demands. A number of studies have shown evidence, however, that people with depression have difficulties in set-shifting, as measured by the Wisconsin Card Sorting Task (WCST; e.g. Must et al., 2006). In an attempt to measure these traits in the context of a complex decision-making task in schizophrenia, Turnbull et al. (2006) modified the standard IGT by including a second phase where previously learnt contingencies were systematically changed. In the modified task, the deck contingencies shifted value across blocks after initial, presumably stable, exposure to the reward and punishment outcomes (Dymond et al., 2010).

The present study sought to explore flexible decision-making performance in patients with major depressive disorder (MDD) with the contingency shifting variant IGT. We hypothesise that patients diagnosed with MDD will perform more poorly on the contingency-shift phases, indicating impaired flexible decision-making.

2. Method

2.1. Participants

Nineteen outpatients with MDD and 20 healthy controls were recruited. Diagnoses were established with a structured clinical interview (SCID; First et al., 1998). Exclusion criteria were history of neurological disorders, presence of medical conditions known to influence cognition, current or past substance abuse problem, and psychosis or manic features. Patients were receiving prescribed antidepressant medications with no less than a month from the last prescription change. Only two patients received adjuvant psychotropic medication (i.e., lithium carbonate).

Healthy controls were selected from the local community based on age, gender and education, and all were psychotropic medication-free and had no history of psychiatric disorders or of neurological or medical conditions known to affect cognition.

2.2. Materials

2.2.1. Beck Depression Inventory, BDI-II (Beck et al., 1996)

The *Beck Depression Inventory-II* (BDI-II) is a 21-item self-report questionnaire assessing depression over the past fortnight. The BDI total score is the sum of the points across the items.

2.2.2. Contingency shifting variant IGT

The contingency shifting variant IGT (Dymond et al., 2010) consisted of 220 trials divided into two phases: 100 trials of the original version of the task (Phase 1), followed by 120 trials involving three successive shifts of the reinforcement contingencies (Phase 2). In Phase 1, participants select cards from four concurrently available decks (labeled sequentially A, B, C and D). A loan of £1000 of virtual money was displayed at the bottom right of the screen and updated immediately following choices with gains and/or losses. Participants always won £100 if they selected a card from the 'disadvantageous' decks (i.e. A and B) and always won £50 if they selected a card from the 'advantageous' decks (i.e. C and D). In addition to a win, a given card could contain a loss. The amount of losses varied between £150 and £350 for deck A (in 5/10 selections); £1250 for deck B (in 1/10 selections); between £25 and £75 for deck C (in 5/10 selections); and £250 for deck D (in 5/10 selections). This phase ended after 100 trials.

In Phase 2, three contingency-shift phases, each consisting of two blocks of 20 trials, were introduced. The onset of each shift phase was not signaled and involved a progressive modification of the reward and punishment contingencies of Phase 1. The advantageous decks (C and D) were successively replaced by decks A and D, A and B, and B and C during the three shift periods (see Dymond et al. (2010) for full details, including instructions). Phase 2 ended after 120 trials.

3. Results

Major depressive disorder patients (MDD) and controls (C) did not differ on mean age, MDD = 35.8(10.1); $C = 35.1$ (9.3), $t(37) = 0.19$, $p > 0.05$, mean number of years of education, MDD = 14.5(2.5); $C = 14.9$ (2.2), $t(37) = 0.56$, $p > 0.05$, gender ratio of male/female, MDD = 1.3; $C = 1$, $\chi^2(1) = 0.62$, $p > 0.05$, and ethnicity (i.e., all white). Mean BDI scores showed a highly significant difference between the two groups, MDD = 30.1 (7.2); $C = 0.9$ (1.1), $t(37) = 17.96$, $p < 0.0001$.

3.1. IGT performance

Mean net score was calculated by subtracting the number of disadvantageous selections from the number of advantageous selections for every block of 20 trials. Fig. 1 shows the

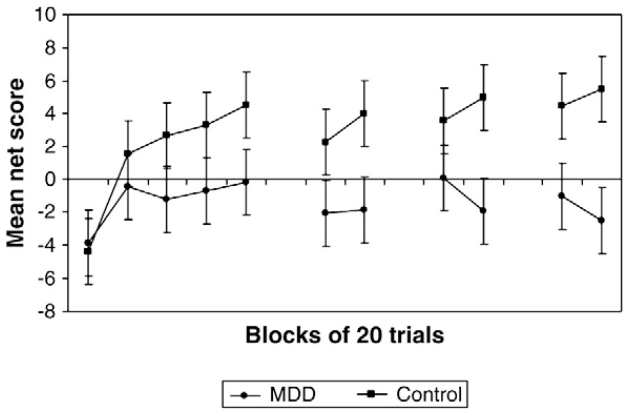

Fig. 1. Mean net score for MDD and the control groups during the five 20-trial blocks of Phase 1 and the six 20-trial blocks of Phase 2.

mean net score performance of the two groups. In Phase 1, the controls appear to show better overall learning, particularly in the latter blocks of the task. In Phase 2, controls showed better levels of learning throughout the three shifts. A 2 (group)×5 (block) mixed factor ANOVA conducted on Phase 1 revealed a main effect of block, $F(4,148)=10.01$, $p<0.0001$, and group, $F(1, 37)=12.48$, $p=0.001$, but no significant interaction, $F(1, 148)= 1.48$, $p=0.21$. Contrast analyses revealed a significant performance improvement for MDD patients and control participants between the first and the second blocks, $F(1,37)=20.09$, $p<0.0001$, but no significant improvement across each of the other blocks (all $p>0.05$). Post-hoc between groups *t*-tests showed that controls performed better in blocks 2, 3, 4 and 5 (all $p<0.05$).

A similar analysis was conducted for Phase 2. A 2 (group)×6 (block) mixed factor ANOVA revealed a significant main effect of group, $F(1,37)=11.37$, $p=0.002$, but no significant interaction, $F(5, 185)=2.11$, $p=0.066$, or block main effect, $F(1, 185)=0.154$, $p=0.98$. Post-hoc between groups *t*-tests conducted on Phase 2 revealed that controls perform better in blocks 7, 9, 10 and 11 (all $p<0.05$).

In order to examine the relationship between depression severity and IGT performance within the MDD group, the relationship between the BDI total score and performance in each IGT block was examined for this group. This analysis showed a strong negative relationship between BDI total score and IGT performance, with significant negative correlations in block 9 ($r=-0.55$, $p<0.05$), block 10 ($r=-0.48$, $p<0.05$) and block 11 ($r=-0.62$, $p<0.001$).

3.2. Deck preferences

To further investigate the lack of advantageous selections in depressed patients during Phase 1, a 5 (blocks)×2 (group) ANOVA was performed for each of the four IGT decks. Results revealed MDD patients showing a preference for deck A over controls, $F(1,37)=3.74$, $p=0.041$, and control participants showing preference for deck D over MDD participants, $F(1,37)=5.24$, $p=0.028$. Levels of Previously Good-Now-Bad selections (PGNB) and Previously Bad-Now-Good (PBNG) were calculated to further explore the cause of the depressed patients' poorer performance during Phase 2. PGNB selections were those from decks of cards that were advantageous in the previous block of trials and become disadvantageous (i.e. deck C for shift 1, deck D for shift 2 and deck A for shift 3). Conversely, PBNG selections were those from decks of cards that were disadvantageous in the previous block of trials and become advantageous (i.e. deck A for shift 1, deck B for shift 2 and deck C for shift 3).

A 2 (group)×3 (shift) mixed factor ANOVA conducted on PGNB selections revealed a significant main effect of group $F(1,37)=8.75$, $p<0.05$. Similar analysis conducted on PBNG selections did not reveal an overall group effect. Follow-up *t*-tests revealed that controls made more selections from the PBNG deck in the last shift, $t(37)=-2.04$, $p=0.04$ (Fig. 2).

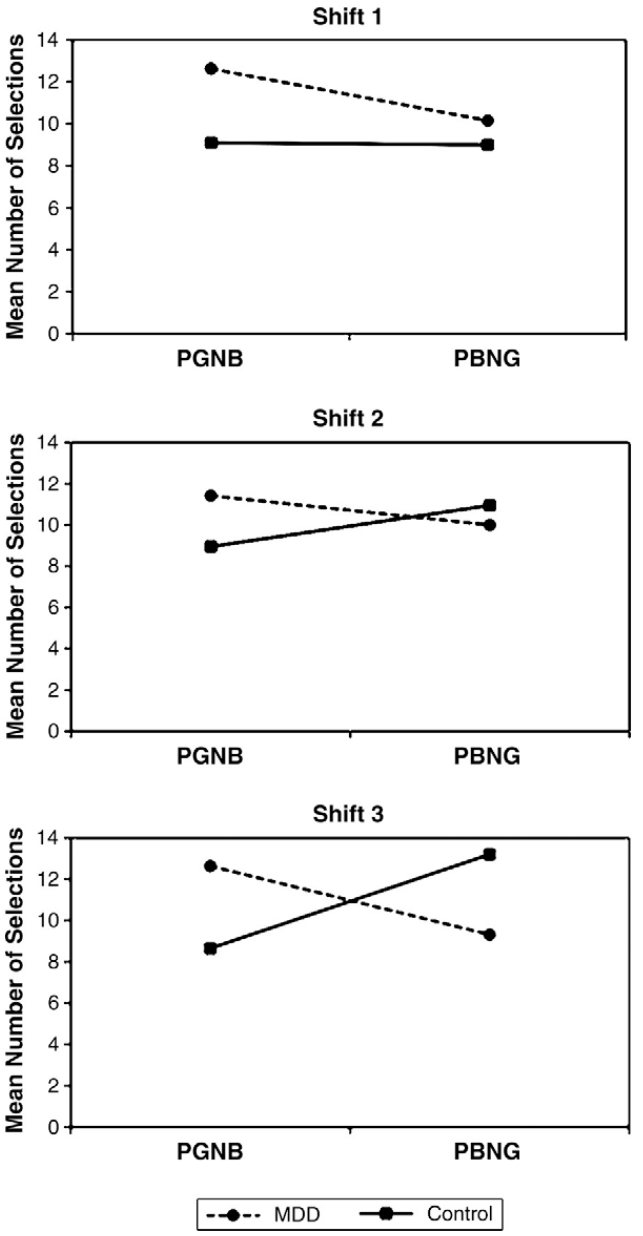

Fig. 2. Mean Previously Good-Now-Bad (PGNB) and Previously Bad-Now-Good (PBNG) selections for MDD and controls during the three shifts of Phase 2.

4. Discussion

Patients diagnosed with MDD displayed impaired performance compared to healthy controls in the final three blocks of the standard IGT. The results from Phase 1 show that MDD patients performed more poorly than controls. Our findings are similar to those of Must et al. (2006), as significant differences between the two groups became evident in the third, fourth and fifth blocks of Phase 1. MDD patients also generally showed poorer performance in the contingency-shift phase of the IGT. The results of Phase 2 show MDD patients with a mean net score constantly below chance and showing no sign of improvement throughout the three consecutive shift periods.

The argument of altered sensitivities to reward and punishment in depression has been used to explain both advantageous and disadvantageous performance in depressed patients compared to controls (e.g., Henriques and Davidson 2000; Sloan et al., 2001). Our results support the view that altered reinforcement sensitivity could be responsible for the poor performance of patients, but suggest a

different picture from Dalgleish et al.'s (2004) hypothesis that learning on the task could be achieved only by paying attention to the punishing stimuli. Compared to controls, MDD patients selected more cards from decks with high-frequency, low-magnitude punishment contingencies (e.g., deck A). This pattern of preference lends only partial support to Dalgleish et al.'s hypothesis that depressed patients avoid high-magnitude punishment, whereas lower magnitude punishment is not perceived as disadvantageous and, hence, is less avoided. On the contrary, control participants tended to prefer cards from decks with low-frequency, high-magnitude punishment (e.g., deck D). These findings do not support an explanation based solely on avoidance of high-magnitude punishment in depression in order to achieve advantageous performance.

Antidepressant medications are known to affect sensitivity to reward and punishment. Dalgleish et al. (2004) suggested that antidepressants may enhance sensitivity to negative outcomes so that they can be perceived and avoided. While enhanced sensitivity to reward and punishment is a crucial target for antidepressants, our PGNB and PBNG findings suggest that in complex decision-making scenarios, sensitivity to positive and negative outcomes is crucial.

PGNB selections showed the depressed group being more attached to the affective consequences of previous positive contingencies and displaying less flexibility in shifting towards new advantageous behaviours. For both control and MDD participants, there seemed to be little adjustment in PGNB selections throughout the three contingency shifts. Controls showed a better ability to disengage from previously good contingencies when they became bad. On the contrary, the ability to shift from bad to good contingences (PBNG) appeared to improve substantially in control participants across shifts but did not change for the MDD group. The performance of controls and MDD patients showed, by the third shift period, a clear example of a double dissociation, where controls showed low PGNB and high PBNG selections and MDD patients showed high PGNB and low PBNG selections.

To conclude, this study showed impaired performance by MDD patients on all phases of the IGT, relative to control participants, and emphasises the role that altered sensitivities to reward and punishment may play in the impaired decision-making often found in depression. In particular, the contingency-shift version of the IGT highlights depressed patients' decision-making difficulties in a changing environment. It should be noted, however, that the current study has several limitations. Firstly, the sample size was relatively small. Secondly, two of the nineteen MDD patients were receiving adjuvant mood stabiliser medication, which may have impaired performance. Thus, the findings can only provide limited insight into the effect of antidepressant medication on flexible decision-making in depression due to the absence of a group of unmedicated MDD patients. Finally, in the absence of other neuropsychological measures, it is difficult to generalise the extent to which findings from the contingency-shift IGT can be extended to cognitive processes measured by other tasks (e.g., executive functions).

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The authors of this study received no special funds for this research.

Conflict of interest

The authors declare that they have no conflicts of interest.

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