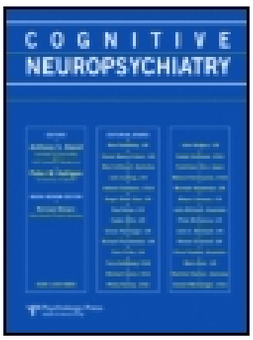

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Decision-making of patients with major depressive disorder in the framework of action control

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ABSTRACT

Introduction: Patients with major depressive disorder (MDD) experience dysfunctional emotional states and cognitive impairments, leading to behavioural, social, and functional issues. Neurocognitive theory proposes that the initiation and maintenance of MDD is primarily the result of a deficit of action control which in turn would lead to decision-making impairments.

Methods: We assessed 27 medicated outpatients with MDD who were demographically matched with 16 healthy participants on decision-making (DM) processes (Iowa Gambling Task (IGT) and Reversal Learning Task (RLT)), clinical variables (depressive symptoms and self-efficacy), and volition (Lille Apathy Rating Scale).

Results: Patients with MDD displayed deficits on the IGT but not on the RLT. Correlational analysis of patients with MDD revealed no significant associations between IGT or RLT performance and volition, depressive symptom severity, and self-efficacy. However, differences on the IGT between patients with MDD and controls became non-significant when controlling for the variance of these scores.

Conclusions: MDD appears to have an impact on dynamic DM processes, while basic processes are preserved. Limitations as well as directions for future research are discussed with regard to the neurocognitive model of depression.

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Major depressive disorder; decision-making; action control; volition

Introduction

Depression is the most prevalent mental disorder across the lifespan, with an estimated prevalence varying from 13.5% to 21.2% (Kessler et al., 2005). Major depressive disorder (MDD) is a mood disorder characterised by a profound state of sadness or loss of interest in activities for a duration of at least two weeks (American Psychiatric Association, 2013).

Depression is primarily considered an affective disorder. However, decades of research have drawn attention to the importance of cognitive functioning in this pathology (McDermott & Ebmeier, 2009). In this context, a specific focus has been decision-making (DM) processes. These are a group of complex cognitive processes requiring choices between several options, through which individuals regulate their actions, thoughts, and emotions according to psychological or physiological states, goals, and environmental conditions (Paulus, 2007). DM depends on the computation of the value

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of available options, which relies on the individual's environment and internal state (Paulus & Yu, 2012).

Indecision is included in the DSM-5 criteria for MDD (American Psychiatric Association, 2013) along with difficulties in thinking and concentrating. More specifically, cognitive theories have proposed that reward processing, an aspect of DM, is implicated in basic pathological processes underlying depression at the behavioural as well as physiological level (Kasch, Rottenberg, Arnow, & Gotlib, 2002; Martin-Soelch, 2009). Depression has been shown to correlate with decreased interest and pleasure in the performance of activities (Epstein et al., 2006). Patients with depression have also been found to show enhanced sensitivity to negative feedback and punishing stimuli (Santesso et al., 2008; Steffens, Wagner, Levy, Horn, & Krishnan, 2001).

The Iowa Gambling Task (IGT) has had a substantial impact on the understanding of the complex aspects of DM. Designed by Bechara, Damasio, Damasio, and Anderson (1994), this task helps model real-life DM settings by relying on contingencies of rewards and penalties. Its development was in line with Damasio's somatic markers hypothesis in which body signals related to rewards and punishment guide behaviour towards long-term beneficial choices (Damasio, 1994). Reviews (de Siqueira et al., 2018; Must, Horvath, Nemeth, & Janka, 2013) on IGT performance in patients with MDD have identified an inability to modulate behaviour as a function of rewards and punishments. More specifically, individuals with MDD show impairments in reward learning and shifting strategies, as well as greater sensitivity to immediate punishments, associated with higher harm/risk avoidance (de Siqueira et al., 2018). However, these results are not completely consistent. Studies have either reported no differences between individuals with depression and controls (Deisenhammer et al., 2018; Gorlyn, Keilp, Oquendo, Burke, & Mann, 2013; Wyart et al., 2015) or better overall performance among individuals with depression (Smoski et al., 2009). However, these results are difficult to generalise owing to heterogeneous populations and protocols (classic or modified version, with or without contingency shift, open access).

Schneider (2009) proposed a neurocognitive theory that considers the role of DM in the initiation and maintenance of MDD in the broader framework of action control. In this context, depression is considered a reduction in the general level of goal-directed behaviour/avolition that could be explained both by the avoidance of situations potentially leading to negative stimuli and a lack of seeking positive stimuli. This theory is based on several hypotheses that support the idea of MDD as a disorder of volition (Kocovski & Endler, 2000; Rehm, 1977; Strauman, 2002; Watkins, 2011). Volition is considered a set of mental steps through which a person voluntarily and consciously links practical reasoning to an intentional action.

Regarding DM processes, Schneider's (2009) theory assumes that, in patients with MDD, depressive mood arises through repeated failures in relevant personal life goals. These failures are perceived through *meta-monitoring* processes that change the perception of actions in terms of negative probabilities. This results in a reduction of approach behaviours and an augmentation of avoidance behaviours. In fact, because of the effect of emotional congruence, depressive mood causes individuals to attribute a greater value to goal-directed actions that are associated with negative feelings and/or negative consequences. This misleading management of probabilities leads to DM impairments that express themselves as a greater difficulty in choosing between approach behaviours and

less difficulty in choosing between avoidance behaviours. Over time, these patterns encode in long-term memory and lead to a reduced sense of self-efficacy, which, in turn, affects probability management and avoidance. This theory implies that: (1) DM impairments are better explained by probability management than by simple reward and punishment processing, (2) impaired probability processes are related to the level of depressive mood and perceived self-efficacy, and (3) impaired probability processes are related to avolition.

As regards the hypothesis of a preserved ability to process simple reward and punishment, previous studies have used a paradigm called Reversal Learning (RL), which involves the integration of positive and negative feedback in order to shift from a previously learned strategy to a new one. Some studies on patients with MDD have highlighted the presence of modified haemodynamic response and error rates on the RL when compared to controls (Remijnse et al., 2009; Robinson, Cools, Carlisi, Sahakian, & Drevets, 2012). However, the RL paradigms are heterogeneous both in form and complexity and complicate direct comparisons between IGT and RLT. Thus, in this study, we used a reversal learning paradigm similar to the IGT setting (choosing cards, winning and losing money). Schneider also proposed that beyond managing simple reward and punishment, overall, patients with MDD fail to make relevant decisions based on the fact that in real-life settings (uncertainty) they tend to attribute more value (i.e., probability management) to goal-directed actions associated with negative feelings/consequences. Although not a probability-based task, the IGT is a classic DM under uncertainty paradigm. As such, we expect that over the course of the task, despite their preserved ability to integrate the processing of punishments and rewards, patients with MDD would manage the task less effectively than controls.

Our study focuses on DM abilities in patients with MDD in the framework of Schneider's (2009) theory of action control. In this context, we explore the relationship between MDD, self-efficacy, volition, reward processing, and DM. We hypothesise that patients with MDD show impairments in the DM process in situations of uncertainty when compared to a control group (de Siqueira et al., 2018; Must et al., 2013), while, according to Schneider's (2009) hypothesis, we expect no impairments in simple reward and punishment processing and switching from a previously learned strategy to a new one in situations of certainty, which is commonly referred to as *reversal learning*. DM, but not reversal learning, should be linked with depressive symptoms, self-efficacy, and volition. More precisely, a high level of depressive symptoms, low self-efficacy, and low volition could moderate the link between MDD and DM abilities.

Methods

Participants

Twenty-seven outpatients from the Psychiatric Hospital St-Bernard in Manage, Belgium and 16 healthy individuals were included in this study. All patients had a diagnosis of MDD according to the DSM-5 criteria (American Psychiatric Association, 2013). Exclusion criteria were a history of neurological disorders, presence of medical conditions known to influence cognition (e.g., neurodevelopmental disorders, ADHD, epilepsy), current or past substance abuse problems, psychotic or manic features, and being under 18 or over 60 years old. All participants were taking antidepressant medication (9 patients

were taking selective serotonin reuptake inhibitors, 10 were taking selective norepinephrine reuptake inhibitors, 7 were taking selective serotonin–norepinephrine reuptake inhibitors and one was taking serotonin reuptake inhibitors) and 24 of them were on anxiolytic medication. Healthy controls were recruited from the local community based on age, gender, and education. They were all medication-free and had no history of psychiatric, neurological, or medical disorders known to affect cognition. Each participant signed an informed consent form. The study was approved by the university as well as the psychiatric hospital's ethics committees.

Materials

IGT and RLT

DM was assessed with two computerised tasks: the IGT and the RLT. In the IGT (Bechara, 2007) participants must choose between four decks of cards (ABCD) from which they are asked to freely pick a card at a time. Although it is not made explicit to the participants, two decks are advantageous (C and D) while the other two are disadvantageous (A and B). A deck is considered advantageous when the immediate gain is low, but in the long run, punishment is also low. Disadvantageous decks imply high immediate reward, but also high losses in the long run. In order to complete the task and maximise their gains, participants must discover the implicit rules according to the feedback they receive after each choice; this implies that, in the long run, they should tend to pick cards from decks C and D. In order to complete the task, participants must win more money than the amount they borrow from the virtual bank. The standard parameters involve 100 trials divided into five blocks, with a 500 ms interval between each trial and 60 cards to pick in each deck. Several scores are computed. The IGT net score is calculated by subtracting the number of disadvantageous selections from the number of advantageous selections (i.e., (C + D)−(A + B)) for the total task, as well as for each of the five blocks. Positive values on this variable indicate that the majority of the choices were from advantageous decks, while negative values indicate a majority of disadvantageous choices. The amount of money at the end of the task is also computed and reveals if the global strategy can be considered successful.

One of the processes implied in the successful management of IGT progression relies on the ability to shift from a learned strategy to a new strategy whenever the former becomes disadvantageous. This ability relates to reward processing and is called *reversal learning*.

The RLT was used to isolate this ability of strategy shifting and reward processing. We developed a task inspired by the paradigm of Fellows and Farah (2003), in which participants are asked to pick a card from one of the two available decks until the end of the task. As in the IGT, they receive instructions to collect as much money as possible. One of the decks is linked with money gains (+50 €) and the other with losses (−50 €). As soon as the participant is considered to have met the *learning criterion* (i.e., he or she picks eight consecutive cards from the "winning deck"), the two decks are inverted: the "winning" and "losing" decks are switched. The task ends as soon as the learning criterion is met; participants have at most 50 trials to complete the task. The scores for the number of errors per condition (learning (Part 1) and reversal learning (Part 2)) and number of trials needed to complete learning and reversal learning were computed.

Lille Apathy Rating Scale

Volition was assessed with the Lille Apathy Rating Scale (LARS) (Sockeel et al., 2006). We chose to isolate apathy as a dimension of volition because it seemed the most suitable concept to illustrate the general reduction of goal-directed behaviours (Marin, 1991) suggested by Schneider (2009). This perspective is congruent with the diagnostic criteria for depression in both the DSM-5 (American Psychiatric Association, 2013) and ICD-11 (Reed et al., 2019; World Health Organization, 2018), in which the dimensions of loss of interest and anhedonia—both related to the nosological concept of apathy—are needed (Starkstein & Leentjens, 2008). The LARS contains nine sets of questions with a standardised rating system. This scale provides four factor scores (interest and curiosity, emotion, action initiation, and self-awareness) and a total score varying between −36 and +36, with lower scores indicating less apathy.

Beck Depression Inventory

Severity of depressive symptoms was assessed with the French version of the Beck Depression Inventory (BDI) (Beck, Steer, & Brown, 1998), a 21-item self-reported questionnaire completed by choosing which of three propositions reflects a participant's feelings during the last two weeks. The total score ranges from 21 to 63.

Self-Efficacy Scale

Self-efficacy was assessed with the French version of the Self-Efficacy Scale (SES) (Chambon et al., 1992; Sherer et al., 1982). It is a self-reported questionnaire including 21 items divided into two sections: 14 items that assess the general feeling of self-efficacy and seven items that measure feelings of self-efficacy in social contexts. Items are scored on a five-point scale: strongly disagree: 1, disagree: 2, neither agree nor disagree: 3, agree: 4, strongly agree: 5. The total score ranges from 21 to 105.

Statistical analysis

Data were analysed using SPSS 21. Descriptive statistics were computed for demographics, clinical variables (SES and BDI), volition (LARS), and DM scores (IGT net score, RLT errors, and number of trials) for each group (control/CTL versus participants with MDD). A one-way ANOVA was conducted to assess intergroup differences for these scores. To further investigate the lack of advantageous selections in patients with MDD from blocks 1 to 5, a 2 (CTL versus MDD) × 4 (number of cards picked from each of the four decks) mixed-model ANOVA was performed. Thereafter, we conducted a 2 (CTL versus MDD) × 5 (blocks of 20 trials) mixed-model ANOVA and post-hoc analyses with *t*-tests for paired samples. The same procedure was conducted with the RLT error scores with a 2 (control versus MDD) × 2 (Part 1 and Part 2) mixed-model ANOVA. Finally, we conducted multivariate general linear model (GLMM) analyses to compare the effect of the interaction between Group (CTL versus MDD) and volition (LARS) on IGT net score and RLT error scores. Correlational analyses were conducted separately in the group with MDD in order to examine the influence of volition on DM scores. Alpha was initially fixed at $p < 0.05$ but was corrected for multiple testing. The same procedure was performed for clinical variables (BDI and SES).

Results

IGT and RLT

Descriptive statistics are reported in Table 1. One-way ANOVA results showed a lower IGT net score for participants with MDD but no significant intergroup differences. Participants with MDD also won significantly less money than controls [$F(1, 42) = 5.44$, $p = 0.025$, Cohen's $d = 0.70$]. Regarding the RLT, the results did not show any significant differences for the number of errors or number of trials in learning and reversal learning.

For the IGT, a one-way ANOVA revealed that participants with MDD chose significantly more cards from deck A [$F(1, 42) = 5.62$, $p = 0.022$, Cohen's $d = 2.03$] and fewer cards from deck C [$F(1, 42) = 6.52$, $p = 0.014$, Cohen's $d = 0.73$] than controls. The mixed-model ANOVA revealed a main effect of Deck [$F(4, 123) = 16.59$, $p < 0.001$], but not Deck X Group [$F(4, 123) = 0.25$, $p = 0.091$]. This indicates that despite intergroup differences, no clear differential pattern of deck preference was observed for participants with MDD.

Learning effects on IGT net score for the control group and participants with MDD are reported in Figure 1. The mixed-model ANOVA revealed a main effect of Block [$F(4, 164) = 7.31$, $p < 0.001$], with all participants choosing fewer disadvantageous cards, therefore making more effective choices over time, and a significant Group X Block [$F(4, 164) = 3.13$, $p = 0.016$], showing a heterogeneous learning path. However, the effect of Group was non-significant [$F(1, 41) = 3.85$, $p = 0.057$].

Table 1. Descriptive statistics and intergroup differences for demographic data, clinical and decision-making scores.

	Control mean ± s.d.	MDD mean ± s.d.	*F*	*p*	Cohen's *d*
Gender	10 women—6 men	18 women—9 men			
Age	42.33 ± 10.74	47.77 ± 8.29	3.25	0.63	
Study (number of years)	13.47 ± 2.56	11.89 ± 2.55	3.65	0.79	
IGT total net score	31 ± 34.74	11.18 ± 29.79	3.93	0.054	0.30
IGT total money	402.19 ± 1715.47	−645.56 ± 1224.41	5.44	0.025*	0.70
IGT Deck a	11.87 ± 5.28	15.67 ± 4.95	5.62	0.023*	2.03
IGT Deck b	22.62 ± 14.11	28.74 ± 12.80	2.22	0.153	0.66
IGT Deck c	29.56 ± 16.77	20 ± 7.64	6.52	0.014*	0.73
IGT Deck d	35.94 ± 16.67	35.59 ± 11.98	0.005	0.945	0.02
RLT errors-part 1	1.75 ± 0.931	3.07 ± 2.83	3.27	0.078	−0.63
RLT errors-part 2	2.31 ± 2.41	1.89 ± 1.55	0.492	0.487	0.21
RLT- number of cards- part 1	11.81 ± 3.60	14.74 ± 7.97	1.91	0.174	0.005
RLT- number of cards-part 2	11.37 ± 3.93	14.33 ± 8.92	1.57	0.218	0.43
LARS total	−28.75 ± 4.40	−14.03 ± 8.89	37.94	0.001***	−2.097
LARS interest and curiosity	−3.25 ± 0.77	−1.29 ± 1.51	22.91	0.001***	1.63
LARS emotion	−2.75 ± 1.61	−2.07 ± 1.49	1.94	0.171	0.44
LARS action initiation	−3.81 ± 0.40	−1.41 ± 1.96	23.14	0.001***	1.69
LARS self-awarness	−3 ± 1.26	−2.18 ± 1.49	3.33	0.075	0.50
SES total	59.37 ± 8.51	44 ± 13.55	16.75	0.001***	1.35
SES general	42.12 ± 7.27	30.40 ± 9.96	16.60	0.001***	1.34
SES social	17.62 ± 4.22	14.33 ± 4.91	4.982	0.031*	0.72
BDI total	4.5 ± 3.85	34.55 ± 12.96	88.20	0.001***	−3.27

Note: IGT = Iowa Gambling Task, RLT = Reversal Learning Test, LARS = Lille Apathy Rating Scale, SES = Self-Efficacy Scale, BDI = Beck Depression Inventory.
*$p < .05$, **$p < 0.01$, ***$p < 0.001$.

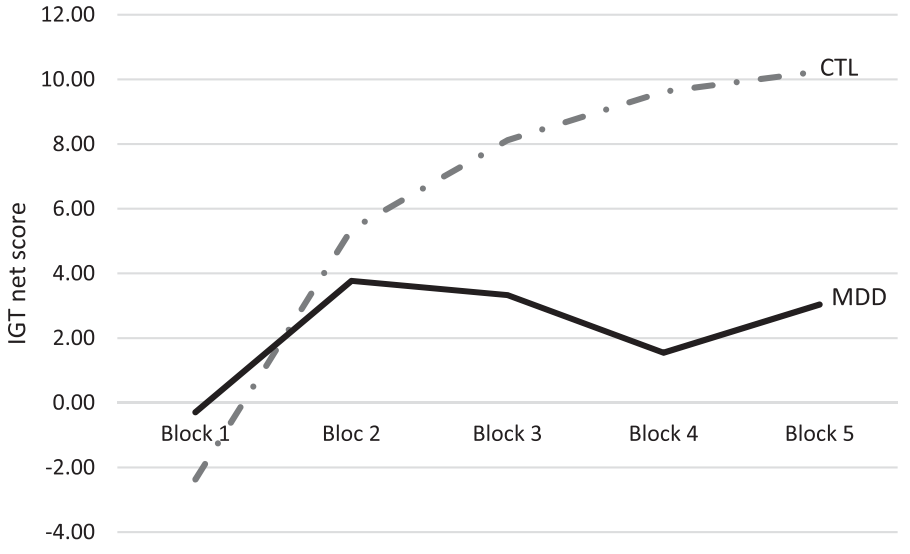

Figure 1. Changes in the IGT net score for major depressive disorder (MDD) and control (CTL) participants of the course of the 100 IGT trials (20 trials per block). The plain line represents participants with major depressive disorder and the dotted line represent the control group.

The mixed-model ANOVA of RLT (Part 1 and Part 2) error scores showed no significant effects of Part [$F(1, 41) = 0.39$, $p = 0.536$], Part X Group [$F(1, 41) = 3.09$, $p = 0.089$], or Group [$F(1, 41) = 1.02$, $p = 0.319$] (Table 2).

Volition

Regarding the influence of action control on DM, we attempted to determine if intergroup differences would remain after controlling for the effect of volition (LARS). Based on LARS cutoff scores, our control sample was composed of 15 individuals with no apathy and one with a tendency towards apathy. Our MDD sample was composed of five individuals without apathy, five with a tendency towards apathy, 11 with moderate apathy, and six with severe apathy. GLMM analyses showed that when controlling for LARS total score, intergroup differences were nonsignificant for IGT net score [$F(1, 43) = 0.08$, $p = 0.773$, partial eta squared = 0.002], IGT total money [$F(1, 43) = 1.91$, $p = 0.175$, partial eta squared = 0.046], errors on RLT Part 1 [$F(1, 43) = 0.33$, $p = 0.566$, partial eta squared = 0.008] and errors on Part 2 [$F(1, 43) = 0.76$, $p = 0.390$, partial eta squared = 0.019]. The

Table 2. post-hoc analysis of repeated-measure ANOVA.

	CTL		MDD	
	t	*p*	*t*	*p*
Block 1- Block 2	−3.35	0.004**	−1.83	0.078
Block 2- Block 3	−1.265	0.225	0.26	0.800
Block 3-Block 4	−0.56	0.580	0.79	0.437
Block 4-Block 5	−0.28	0.783	−0.67	0.509

Note: CTL = control group, MDD = participants with major depressive disorder, FE = first episode, ME = multiple-episode.
*$p < 0.05$, **$p < 0.01$.

results of correlational analyses are reported in Table 3. When the significance level was adjusted for multiple testing ($p < 0.001$), none of the LARS scores (total score and factor scores) significantly correlated with IGT or RLT scores in the group with MDD.

Severity of depressive symptoms and self-efficacy

The same procedure was conducted with clinical variables (BDI and SES total scores) as co-variables. GLMM analyses showed that when controlling for BDI and SES scores, inter-group differences turned out to be non-significant for IGT net score [$F(1, 43) = 0.52$, $p = 0.689$, partial eta squared = 0.013], IGT total money [$F(1, 43) = 0.16$, $p = 0.689$, partial eta squared = 0.004], errors on RLT Part 1 [$F(1, 43) = 0.25$, $p = 0.621$, partial eta squared = 0.007] and errors on Part 2 [$F(1, 43) = 1.06$, $p = 0.310$, partial eta squared = 0.027]. The results of correlational analyses are reported in Table 3. When the significance level was adjusted for multiple testing ($p < 0.001$), none of the BDI or SES (total, general, and social) scores were significantly correlated with IGT or RLT scores in the group with MDD.

Discussion

This study involved an exploratory analysis of DM in the framework of Schneider's theory of action control by comparing performances of patients with MDD with those of a control group on measures of DM (IGT) and reversal learning (RLT), as well as clinical variables such as severity of depressive symptoms (BDI), self-efficacy (SES), and volition (LARS). The aim of this study was therefore to replicate previous analysis using the IGT in sample of individuals with major depressive disorder with a specific emphasis on the impact of action control.

Consistent with previous studies (Deisenhammer, Schmid, Kemmler, Moser, & Delazer, 2018; Gorlyn et al., 2013; Wyart et al., 2015), all participants learned to avoid

Table 3. Pearson correlations between clinical variables and decision-making scores.

		RLT errors/part 1	RLT errors/part 2	IGT total net score	IGT money
BDI total	*r*	−0.035	0.171	−0.261	−0.232
	p	0.862	0.393	0.189	0.243
SES general	*r*	0.021	−0.241	0.147	0.089
	p	0.918	0.227	0.466	0.659
SES social	*r*	−0.279	0.171	0.083	0.035
	p	0.159	0.393	0.679	0.864
SES total	*r*	−0.064	−0.082	0.152	0.126
	p	0.750	0.683	0.450	0.532
LARS self-awareness	*R*	−0.069	0.007	0.155	0.201
	p	0.731	0.971	0.439	0.315
LARS interest	*r*	0.050	−0.211	−0.173	−0.084
	p	0.803	0.291	0.389	0.679
LARS emotion	*r*	0.539	−0.070	0.118	0.257
	p	0.004	0.728	0.558	0.195
LARS action and initiative	*r*	0.116	−0.041	−0.196	−0.156
	p	0.563	0.841	0.326	0.436
LARS total	*r*	0.234	−0.198	−0.144	−0.031
	p	0.240	0.322	0.473	0.879

Adjusted significance for multiple-testing: $p < 0.001$. IGT = Iowa Gambling Task, RLT = Reversal Learning Test, LARS = Lille Apathy Rating Scale, SES = Self-Efficacy Scale, BDI = Beck Depression Inventory.

the disadvantageous decks over the course of the IGT, with intergroup differences for the IGT total net score being only close to significant. However, performance on IGT could still be considered suboptimal as progression through the task (ability to choose less disadvantageous cards between each block) was lower in the group with MDD compared to control participants, and they also showed a trend towards losing money. Decks A and B are considered disadvantageous because although the gains are higher, in the long run, punishments surpass rewards. On the contrary, decks C and D have smaller gains but advantageous final outcomes. Decks A and C both have small gains and small losses, with frequent small punishments (five gains and five losses), while decks B and D have higher gains and higher but more infrequent losses (nine gains and one loss).

Participants with MDD tended to choose more cards in deck A (disadvantageous, but with frequent low losses) and fewer cards in deck C (advantageous, but with frequent low losses) than controls. As previously highlighted by Cella, Dymond, and Cooper (2010), this pattern is not fully consistent with Dalgleish et al.'s (2004) hypothesis that patients with depression avoid high-magnitude punishments, whereas lower-magnitude punishments are not perceived as disadvantageous and, therefore, are less likely to be avoided. In our case, the pattern displayed by participants with MDD suggests that they take into consideration more frequent and sufficiently large reinforcements irrespective of punishment and loss frequency. This is congruent with results showing that besides maladaptive responses to punishments (which could lead to avoidance of negative feedback), patients with MDD also display a behavioural and biological hyposensitivity for positive reinforcements (Eshel & Roiser, 2010) (which, in this case, could have led to avoiding the smaller-gain deck C).

Consistent with our hypothesis, we found no intergroup differences in RLT either for score or progression between the learning and reversal learning conditions. The ability to shift from a previously learned strategy to a new one based on feedback under certainty was, therefore, unimpaired in our MDD sample. This is consistent with previous studies using reversal learning and showing that while control and MDD subjects show similar accuracy on tasks, differences emerge from examination of associated neural pathways, especially in the limbic system (Remijnse et al., 2009). This is also consistent with Schneider's assumptions about impairment in DM management being limited to uncertainty and risk management while more straightforward forms of feedback processing are preserved.

Success in reversal learning implies both feedback processing and the ability to shift from a previously learned strategy. The RLT task, unfortunately, does not allow isolation of these processes. Using the classic, as well as the contingency-shift paradigm of the IGT, Cella et al. (2010) found that individuals with MDD showed poorer performances than controls on both versions. More specifically, they had a lower ability to perceive that a bad condition became good in the shifting paradigm. It is, therefore, likely that, in this study, neither basic reward processing impairments nor inflexibility would explain DM impairments, which may instead be linked to difficulties in managing probabilities under uncertainty.

Contrary to what we expected regarding Schneider's framework, we failed to observe any significant correlation between volition as measured by the LARS and any aspect of the IGT or RLT. In this design, lack of volition observed in MDD cannot be related to impaired DM. It is possible that motivational theories of behaviour would have been

more suitable to capture the dynamic processing of reward and punishment and its influence on DM in MDD. As such, we cannot eliminate the possibility that a specific focus on reward sensitivity (measured with the Behavioural Inhibition System/Behavioral Activation System scales (Carver & White, 1994) or the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) (Lardi, Billieux, d'Acremont, & Van der Linden, 2008)) could facilitate a better understanding of the behavioural dimension of the action control theory of MDD. It is interesting to note that when volition was controlled in both groups, the small intergroup differences in the IGT became nonsignificant. The same pattern, that is the absence of significant correlations and absence of intergroup differences once controlled, was observed for the severity of depressive symptoms and self-efficacy. This might suggest that volition, severity of depressive symptoms, and self-efficacy *are* relevant dimensions for understanding DM in MDD, but should be considered a continuum, whose dynamic interaction may lead to specific vulnerabilities, irrespective of the presence of a diagnosed disorder.

A study by McGovern et al. (2014) also elicited an unexpected result regarding apathy, with older individuals with depression displaying near-normal IGT performance and apathetic individuals displaying above-normal performance. However, this better performance was related to the fact that apathetic elderly participants with depression selected more cards from the advantageous/conservative deck. McGovern et al. interpreted this conservative pattern as a behavioural probe of the positive valence system that may reflect either a reduced need to seek rewarding experiences, or a reduced sensitivity to rewards. This was not the case for our study. However, it is unlikely that avolition would have no impact on DM. One possible explanation is that besides rewards and punishments, volitional aspects of DM also imply effort estimation and computation (Bonnelle et al., 2015), which is not a directly investigated dimension of the IGT.

In conclusion, only parts of our data are congruent with Schneider's (2009) hypothesis. Our results indeed highlight the fact that DM impairments are better explained by impaired dynamic and uncertain reward and punishment integration than by simple feedback processing, as RLT performances were highly stable across groups and analyses. However, correlational analyses did not allow us to observe that these impaired processes are related to the level of depressive mood and perceived self-efficacy, avolition, and poverty of actions exclusively in the group with MDD.

There are some limitations to this study. First is the choice of self-reported clinical measures. In order to comprehensively understand the relevance of Schneider's theory of action control in the context of depression, there is a need for a specific focus on volition with either supplementary behavioural (e.g., BIS/BAS, SPSRQ) or electrophysical measures. Second, although representing the gold standard of DM protocols, the IGT does not allow differentiation between approach and avoidance behaviours. Finally, the sample size and composition did not allow for comparison between first-episode and multiple-episode MDD participants, which would have been useful to assess the chronicity hypothesis of Schneider's theory.

Although these results should be considered exploratory and need replication, they represent the first attempt to systematically investigate the association between basic and dynamic DM processes and clinical features. This study provides perspective on the IGT, also helping clarify some inconsistencies in the existing literature. Considering suboptimal DM processes in depressed individuals seems valuable from a clinical perspective

because misperceptions of rewards and punishments in dynamic settings might enhance cognitive/attentional bias towards avoiding positive stimuli and searching for mood-congruent stimuli (Hallion & Meron Ruscio, 2011), which, in turn, could drive patients away from effective protective factors such as searching for social support, self-esteem improvement, or developing coping strategies.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders, Fifth Edition, DSM-5*. Arlington.

Bechara, A. (2007). *Iowa gambling task : Professional manual*. Lutz: Psychological Assessment Resources.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*(1–3), 7–15. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8039375

Beck, A. T., Steer, R. A., & Brown, G. K. (1998). *Inventaire de dépression de Beck, 2e édition (BDI-II)*. Paris: Éditions du Centre de psychologie appliquée (ECPA).

Bonnelle, V., Veromann, K., Burnett, S., Lo, E., Manohar, S., & Husain, M. (2015). Characterization of reward and effort mechanisms in apathy. *Journal of Physiology - Paris*, *109*(1–3), 16–26. doi:10.1016/j.jphysparis.2014.04.002

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology*, *67*(2), 319–333. doi:10.1037/0022-3514.67.2.319

Cella, M., Dymond, S., & Cooper, A. (2010). Impaired flexible decision-making in major depressive disorder. *Journal of Affective Disorders*, *124*(1–2), 207–210. doi:10.1016/j.jad.2009.11.013

Chambon, O., Cornillon-Jacouton, D., Germain, M. H., Assouline, B., Landazuri, F., & Marie-Cardine, M. (1992). Bien-être subjectif et qualité de vie: Définitions, mesures et facteurs déterminants. *L'Information Psychiatrique*, *5*.

Dalgleish, T., Yiend, J., Bramham, J., Teasdale, J. D., Ogilvie, A. D., Malhi, G., & Howard, R. (2004). Neuropsychological processing associated with recovery from depression after stereotactic subcaudate tractotomy. *American Journal of Psychiatry*, *161*(10), 1913–1916.

Damasio, A. R. (1994). Descartes' error and the future of human life. *Scientific American*, *271*(4), 144–144. doi:10.1038/scientificamerican1094-144

Deisenhammer, E. A., Schmid, K., Kemmler, G., Moser, B., & Delazer, M. (2018). Decision making under risk and under ambiguity in depressed suicide attempters, depressed non-attempters and healthy controls. *Journal of Affective Disorders*, *226*, 261–266. doi:10.1016/j.jad.2017.10.012

de Siqueira, A. S. S., Flaks, M. K., Biella, M. M., Mauer, S., Borges, M. K., & Aprahamian, I. (2018). Decision making assessed by the Iowa Gambling Task and major depressive disorder: A systematic review. *Dementia e Neuropsychologia*, *12*(3), 250–255. doi:10.1590/1980-57642018dn12-030005

Epstein, J., Pan, H., Kocsis, J. H., Yang, Y., Butler, T., Chusid, J., … Silbersweig, D. A. (2006). Lack of ventral striatal response to positive stimuli in depressed versus normal subjects. *American Journal of Psychiatry*, *163*(10), 1784–1790. doi:10.1176/ajp.2006.163.10.1784

Eshel, N., & Roiser, J. P. (2010). Reward and punishment processing in depression. *Biological Psychiatry*, *68*(2), 118–124. doi:10.1016/j.biopsych.2010.01.027

Fellows, L. K., & Farah, M. J. (2003). Ventromedial frontal cortex mediates affective shifting in humans: Evidence from a reversal learning paradigm. *Brain*, *126*(8), 1830–1837. doi:10.1093/brain/awg180

Gorlyn, M., Keilp, J. G., Oquendo, M. A., Burke, A. K., & Mann, J. J. (2013). Iowa gambling task performance in currently depressed suicide attempters. *Psychiatry Research*, *207*(3), 150–157. doi:10.1016/j.psychres.2013.01.030

Hallion, L. S., & Meron Ruscio, A. (2011). A meta-analysis of the effect of cognitive bias modification on anxiety and depression. *Psychological Bulletin*, *137*(6), 940–958.

Kasch, K. L., Rottenberg, J., Arnow, B. A., & Gotlib, I. H. (2002). Behavioral activation and inhibition systems and the severity and course of depression. *Journal of Abnormal Psychology*, *111* (4), 589–597. doi:10.1037/0021-843X.111.4.589

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry*, *62*, 593–602. doi:10.1001/archpsyc.62.6.593

Kocovski, N., & Endler, N. (2000). Self-regulation: Social anxiety and depression. *Journal of Applied Biobehavioral Research*, *5*(1), 80–91.

Lardi, C., Billieux, J., d'Acremont, M., & Van der Linden, M. (2008). A French adaptation of a short version of the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ). *Personality and Individual Differences*, *45*(8), 722–725. doi:10.1016/j.paid.2008.07.019

Marin, R. S. (1991). Apathy: A neuropsychiatric syndrome. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *3*(3), 243–254.

Martin-Soelch, C. (2009). Is depression associated with dysfunction of the central reward system? *Biochemical Society Transactions*, *37*(1), 313–317. doi:10.1042/BST0370313

McDermott, L. M., & Ebmeier, K. P. (2009). A meta-analysis of depression severity and cognitive function. *Journal of Affective Disorders*, *119*(1–3), 1–8. doi:10.1016/j.jad.2009.04.022

Mcgovern, A. R., Alexopoulos, G. S., Yuen, G. S., & Morimoto, S. S. (2014). Reward-related decision making in older adults: Relationship to clinical presentation of depression. *International journal of geriatric psychiatry*, *29*(11), 1125–1131.

Must, A., Horvath, S., Nemeth, V. L., & Janka, Z. (2013). The Iowa Gambling Task in depression - what have we learned about sub-optimal decision-making strategies? *Frontiers in Psychology*, *4*, 1–6. doi:10.3389/fpsyg.2013.00732

Paulus, M. P. (2007). Decision-making dysfunctions in psychiatry - Altered homeostatic processing? *Science*, *318*(5850), 602–606. doi:10.1126/science.1142997

Paulus, M. P., & Yu, A. J. (2012). Emotion and decision-making: Affect-driven belief systems in anxiety and depression. *Trends in Cognitive Sciences*, *16*(9), 476–483. doi:10.1016/j.tics.2012.07.009

Reed, G. M., First, M. B., Kogan, C. S., Hyman, S. E., Gureje, O., Gaebel, W., … Saxena, S. (2019). Innovations and changes in the ICD-11 classification of mental, behavioural and neurodevelopmental disorders. *World Psychiatry*, *18*(1), 3–19. doi:10.1002/wps.20611

Rehm, L. P. (1977). A self-control model of depression. *Behavior Therapy*, *8*, 787–804.

Remijnse, P. L., Nielen, M. M. A., Van Balkom, A. J. L. M., Hendriks, G. J., Hoogendijk, W. J., Uylings, H. B. M., & Veltman, D. J. (2009). Differential frontal-striatal and paralimbic activity during reversal learning in major depressive disorder and obsessive-compulsive disorder. *Psychological Medicine*, *39*(9), 1503–1518. doi:10.1017/S0033291708005072

Robinson, O. J., Cools, R., Carlisi, C. O., Sahakian, B. J., & Drevets, W. C. (2012). Ventral striatum response during reward and punishment reversal learning in unmedicated major depressive disorder. *American Journal of Psychiatry*, *169*(2), 152–159. doi:10.1176/appi.ajp.2011.11010137. Ventral

Santesso, D. L., Steele, K. T., Bogdan, R., Holmes, A. J., Deveney, C. M., Meites, T. M., & Pizzagalli, D. A. (2008). Enhanced negative feedback responses in remitted depression. *NeuroReport*, *19* (10), 1045–1048. doi:10.1097/WNR.0b013e3283036e73

Schneider, W. X. (2009). Action control and its failure in clinical depression: A neurocognitive theory. In N. Sebanz & W. Prinz (Eds.), *Disorders of volition* (pp. 275–306). Cambridge: MIT Press.

Sherer, M., Maddux, J. E., Mercandante, B., Prentice-Dunn, S., Jacobs, B., & Rogers, R. W. (1982). The self-efficacy scale: Construction and validation. *Psychological Reports*, *51*, 663–671. doi:10.2466/pr0.1982.51.2.663

Smoski, M. J., Lynch, T. R., Rosenthal, M. Z., Cheavens, J. S., Chapman, A. L., & Krishnan, R. R. (2009). Decision-making and risk aversion among depressive adults. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*(4), 567–576. doi:10.1016/j.jbtep.2008.01.004. Decision-Making

Sockeel, P., Dujardin, K., Devos, D., Denève, C., Destée, A., & Defebvre, L. (2006). The Lille Apathy Rating Scale (LARS), a new instrument for detecting and quantifying apathy: Validation in Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry*, *77*(579–584).

Starkstein, S. E., & Leentjens, A. F. G. (2008). The nosological position of apathy in clinical practice. *Journal of Neurology, Neurosurgery, and Psychiatry*, *79*(10), 1088–1092. doi:10.1136/jnnp.2007.136895

Steffens, D. C., Wagner, H. R., Levy, R. M., Horn, K. A., & Krishnan, K. R. R. (2001). Performance feedback deficit in geriatric depression. *Biological Psychiatry*, *50*(5), 358–363. doi:10.1016/S0006-3223(01)01165-9

Strauman, T. J. (2002). Self-regulation and depression. *Self and Identity*, *1*, 151–157. doi:10.1080/152988602317319339

Watkins, E. (2011). Dysregulation in level of goal and action identification across psychological disorders. *Clinical Psychology Review*, *31*(2), 260–278. doi:10.1016/j.cpr.2010.05.004

World Health Organization. (2018). *International statistical classification of diseases and related health problems* (11th Rev.).

Wyart, A. M., Jaussent, I., Ritchie, K., Abbar, M., Jollant, F., & Courtet, P. (2015). Iowa Gambling Task performance in elderly Persons with a lifetime history of suicidal acts. *The American Journal of Geriatric Psychiatry*, *24*(5), 399–406. doi:10.1016/j.jagp.2015.12.007