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BRIEF REPORT

Performance Benefits of Depression: Sequential Decision Making in a Healthy Sample and a Clinically Depressed Sample

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Previous research reported conflicting results concerning the influence of depression on cognitive task performance. Whereas some studies reported that depression enhances performance, other studies reported negative or null effects. These discrepant findings appear to result from task variation, as well as the severity and treatment status of participant depression. To better understand these moderating factors, we study the performance of individuals—in a complex sequential decision task similar to the secretary problem—who are nondepressed, depressed, and recovering from a major depressive episode. We find that depressed individuals perform better than do nondepressed individuals. Formal modeling of participants' decision strategies suggested that acutely depressed participants had higher thresholds for accepting options and made better choices than either healthy participants or those recovering from depression.

Keywords: decision making, major depressive disorder, sequential choice

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Major depressive disorder (MDD) is the most common psychiatric diagnosis worldwide, with an estimated life prevalence reaching 20% (Kessler & Wang, 2009). Though most recognize depression's pervasiveness and its characteristic influence on affect, scholars debate depression's impact on cognition. One line of reasoning contends that depression impedes cognitive functioning such as memory or problem solving (for current reviews, see Gotlib & Joormann, 2010; Hammar & Ardal, 2009). This perspective receives support from research showing that depression produces deficits in higher order cognitive tasks, such as reasoning (e.g., Sedek & von Hecker, 2004) and decision making (e.g., Cella, Dymond, & Cooper, 2010; Conway & Giannopoulos, 1993). One explanation for these deficits concerns rumination: Depression may lead to rumination about the problem causing depression, and that rumination may consume cognitive resources, thus diminishing performance in laboratory tasks (Andrews & Thompson, 2009; Ellis & Ashbrook, 1988). Consistent with this theory, Hertel and Rude (1991) showed that depressed individuals perform better when experimenters prevent rumination.

Further studies complicate this picture, however, by providing evidence that depressed individuals perform as well as (Kyte, Goodyer, & Sahakian, 2005) or better than (Costello, 1983; Lane & DePaulo, 1999; Smoski et al., 2008) nondepressed individuals in some complex tasks. Several explanations have been offered to account for these findings. First, depressed individuals seem to process information more systematically and analytically than do nondepressed individuals. This could result from increased negative affect, which appears to initiate deliberate and analytical

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information processing (Bless, Bohner, Schwarz, & Strack, 1990; Bless & Fiedler, 2006; Schwarz & Clore, 2003). Furthermore, Weary and colleagues (e.g., Edwards & Weary, 1993; Gleicher & Weary, 1991) argued that more effortful information processing by depressed individuals might result from those individuals' desire to exert control over their environment.

Second, depression might enhance cognitive performance in undertakings that require accurate assessments of task requirements. For instance, studies reported that depressed individuals' performance improves in contingency assessment or self-evaluation tasks (Alloy & Abramson, 1979). Strunk and Adler (2009) suggested that this increase in performance results from a pessimistic worldview that leads to a realistic assessment in a task where nondepressed individuals misjudge due to a positivity bias.

These mechanisms challenge theories holding that depression hinders cognition. However, as the above discussion implies, evidence supports both lines of reasoning. Thus, other factors—such as the type of task (e.g., Von Hecker, Sedek, & McIntosh, 2000), the severity of depression, and the status of treatment—may moderate depression's influence on cognition.

Studies reporting performance increases frequently involved participants with subclinical depression (e.g., Lane & DePaulo, 1999), whereas many studies reporting deficits used clinical samples (e.g., Cella et al., 2010). With these studies in mind, scholars proposed a nonlinear relation between depression and performance, with moderate levels enhancing performance and high levels reducing performance (e.g., Harkness, Sabbagh, Jacobson, Chowdrey, & Chen, 2005; Lee, Harkness, Sabbagh, & Jacobson, 2005). Evidence also suggests that cognitive performance fluctuates with treatment and depressive symptoms. For instance, treatment with selective serotonin reuptake inhibitors (SSRI) leads to an improvement in cognitive functioning, though often not to the level of a healthy comparison sample (e.g., Herrera-Guzmán et al., 2009). Also, comparisons between recovered patients (without medication) and healthy participants show that although cognitive functioning rebounds after depression, small deficits may remain (e.g., Baune et al., 2010). This suggests that changes in cognitive performance may depend on depression severity and treatment status.

To better understand how these factors influence depression's effect on cognitive performance, we investigate performance in a sequential choice task in a sample of individuals who are depressed, nondepressed, and recovering from depression. In so doing, we offer insight into how the level and treatment status of depression influences performance on a complex cognitive decision-making task, thereby clarifying the conditions in which depression influences cognition.

Sequential Choice

In many decision problems, options can only be judged sequentially—one at a time—and they may not be available once rejected. For instance, a rejected partner will lose interest if you court others. An employer will select another applicant if you will not sign a contract until hearing back from other firms. In each of these sequential choice tasks, the challenge is when to stop searching. Searching too little means you might never encounter the best option; searching too much carries the risk of passing over the best option.

The classic paradigm for studying sequential choice is the secretary problem. In the secretary problem, an individual attempts to select the best job candidate out of a sequentially presented pool of applicants (Ferguson, 1989). The decision maker possesses no prior knowledge about the distribution of applicants' quality, and applicants are presented in a random order. Further exacerbating the problem, once rejected, applicants cannot be recalled.

Formal analysis of the secretary problem indicates that the task's optimal solution is a threshold strategy. First, to set the threshold, examine a number of candidates to gain insight into the distribution of candidate quality. After considering sufficient candidates, set a threshold equivalent to the best option seen thus far. Then, choose the next option that exceeds the threshold (Ferguson, 1989).

In many empirical investigations, researchers have examined human decision making in the secretary problem and found that the threshold strategy accurately models human behavior. However, participants often set their threshold too low, thus producing suboptimal performance (e.g., Bearden, Rapoport, & Murphy, 2006; Seale & Rapoport, 1997, 2000).

Here we add to this line of inquiry by investigating how depression affects performance in sequential decision making. Sequential decision making provides a useful paradigm to understand the influence of depression on cognitive performance because performance correlates with cognitive ability (Burns, Lee, & Vickers, 2006). Thus, if depression impedes cognitive functioning, then depressed individuals should perform worse than nondepressed individuals should. On the other hand, if depression promotes a realistic assessment of options and systematic processing, then depressed participants should perform better than nondepressed individuals should.

Method

We investigated how individuals—who were healthy, depressed, and recovering from depression—performed in a sequential decision-making task similar to the secretary problem.

Participants

The depressed sample consisted of inpatients of the Medical Clinic for Internal Medicine and Psychosomatics at the Charité Hospital in Berlin. Participants at Charité were accepted for testing if they were diagnosed as having a major depressive episode and scored 10 or higher on the depression module of the German version of the Patient Health Questionnaire (PHQ-D; Löwe, Spitzer, Zipfel, & Herzog, 2002) at admission. Of the 37 patients that initially agreed to participate in the study, 27 completed the behavioral tests and questionnaires.[1] A control sample approximately matched by gender, age, and education was tested in the laboratory of the Max-Planck-Institute for Human Development in Berlin (MPI). They were community dwelling adults recruited from the MPI participant database. The final sample consisted of

[1] Due to technical difficulties with the choice task, we had to exclude 10 participants that initially agreed to participate and filled out questionnaires. The excluded participants did not differ from the included participants in terms of severity of depression, days passed since admission, medication, age, or education.

27 participants at Charité (M_{age} = 38.8 years, *SD* = 10.4; nine males, 18 females) and 27 participants at the MPI (M_{age} = 39.1 years, *SD* = 10.6, 10 males, 17 females). Participants at Charité completed the study within the first 3 weeks of their ward stay. Because the delay between admittance and participation differed between participants, we compared PHQ-D scores collected at admission to the PHQ-D scores at test time. Because several participants improved their PHQ-D scores, we split the depressed sample into two subsamples: one showing a level of depression similar to that measured at admission and one showing recovery. On the basis of the distribution of improvements in the PHQ-D indicating two groups, we assigned participants to the depressed sample if their PHQ-D scores had improved by less than 2 points. This resulted in an approximate median split, with 15 participants in the depressed sample and 12 participants in the recovered sample. The recovery group had been admitted slightly—but not significantly—longer than the depressed group ($p > .26$; see Table 1). In both groups, about half of the participants received medication: 26% received SSRIs (two participants received additional antipsychotic or antiepileptic medication), 4% received norepinephrine reuptake inhibitors, 19% received tricyclic or tetracyclic antidepressants, and a single participant received a serotonin–norepinephrine reuptake inhibitor. No significant differences in medication existed between the recovery and the depressed group ($p > .50$). Participation lasted about 45 min, and participants received roughly 8€ (about U.S.$10) in compensation, though exact payment depended on performance.

Design and Procedure

The sequential decision-making task was conducted as a computer-based experiment (Czienskowski, 2006). Depression was measured with the German version of the Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996; Hautzinger, Beiler, Worall, & Keller, 1994). At the MPI, participants filled out the BDI at the end of the testing session. In Charité, the PHQ-D was completed at admission. Two days before the sequential decision-making task was conducted in an individually scheduled session at the hospital, the BDI and the PHQ-D (for a second time) were completed.

Sequential Decision-Making Task

The sequential decision-making task consisted of playing 30 games of a secretary-type problem. Each game challenged participants to find the best candidate for a job out of a sequence of 40 applicants. The 40 applicants were presented one after another, in a random sequence. After an applicant was presented, participants needed to decide whether they would accept the applicant or not. If they accepted the applicant, the game concluded and the next game started. If they rejected the applicant, the next applicant was presented. Rejected applicants could not be chosen later in that game. If a participant did not make a decision before seeing the last applicant in a game, he had to accept the final applicant. To ensure that they could not learn the distribution of candidate quality, participants were informed only about an applicant's relative rank. That is, participants only learned how good the current applicant was compared with other applicants seen in the game thus far (see Figure 1). Performance and payment depended on the absolute rank of the chosen candidate. Participants received 40 points for the best, 39 for the second best and so on. After the task, experimenters exchanged points for Euros at a rate of 100 points = 0.30€. Before each game, experimenters asked participants to indicate their personal goal for the game by specifying how good a chosen candidate would need to be to leave them satisfied with their choice.

Questionnaires

BDI. The Beck Depression Inventory (German version; Hautzinger et al., 1994) reliably measures symptoms of a depressive disorder with 21 items (Richter, Werner, & Bastine, 1994). Persons with scores ranging from 14–19 are considered mildly depressed, 20–28 moderately depressed, and 29–63 severely depressed. Reliability in our sample was high (Cronbach's $\alpha = .93$).

PHQ-D. German version of the PHQ-D (Löwe et al., 2002; Löwe, Kroenke, Herzog, & Gräfe, 2004) was used. The depression module of the PHQ consists of nine items measuring depressive symptoms such as depressive mood, suicidal thoughts, or concentration deficits; studies identify it as a highly reliable tool for screening depression (e.g., Löwe et al., 2004). Participants with scores ≥ 10 are considered clinically depressed. Reliability in our sample was low (Cronbach's $\alpha = .56$).

Results

Depression Questionnaires

We ran an analysis of variance (ANOVA) with BDI scores as the dependent variable and participant group (healthy, recovered, and depressed) as the independent variable, finding a group effect,

Table 1
Depression Scores

Measure	Healthy		Recovered		Depressed	
	M	*SD*	*M*	*SD*	*M*	*SD*
BDI	6.63	5.25	16.67	9.93	29.13	9.91
PHQ-D Time 1			17.33	3.63	16.73	4.01
PHQ-D Time 2			10.17	4.32	17.00	4.07
Days of hospitalization			6.25	4.92	4.20	4.41

Note. Healthy $n = 27$; recovered $n = 12$; depressed $n = 15$. BDI = Beck Depression Inventory; PHQ-D = German version of the Patient Health Questionnaire.

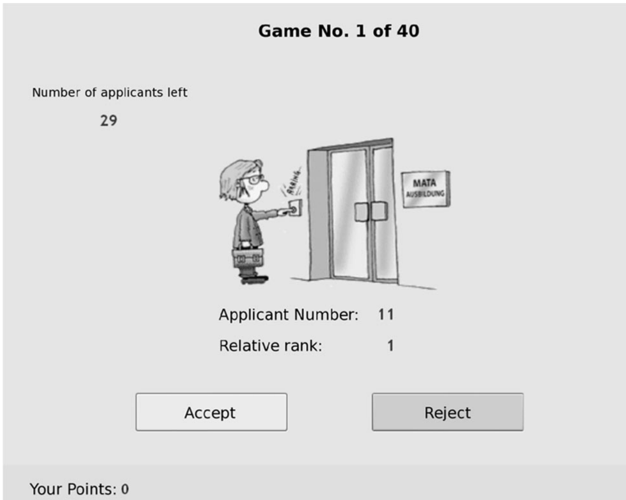

Figure 1. A screenshot of the task. The information participants can use for their decision are the number and the relative rank of the applicant. No. = number.

$F(2, 51) = 39.52$, $p < .001$. Follow-up contrasts showed that healthy participants had significantly lower BDI scores than did recovered participants, $t(51) = 3.67$, $p < .001$, and depressed participants had significantly higher BDI scores than did recovered participants, $t(51) = 8.86$, $p < .001$ (see Table 1).

Secretary Problem

To investigate how participants solved the secretary problem, we considered several measures: the median number of points earned per game (i.e., performance), the median number of options searched per game (i.e., search length), the median relative rank of chosen options, and the median self-reported goals (see Table 2). An ANOVA on search length showed no significant group differences, $F(2, 51) = 2.70$, $p = .08$. Because performance, relative rank, and self-reported goals were not normally distributed, we tested group differences on these measures with the nonparametric Kruskal-Wallis test. We found no significant differences in performance goals, $\chi^2(2, N = 54) = 0.33$, $p = .85$, or relative rank, $\chi^2(2, N = 54) = 1.50$, $p = .47$. Participant groups differed in performance, $\chi^2(2, N = 54) = 8.32$, $p = .02$. Follow-up Mann-Whitney U-tests comparing participant groups showed that depressed participants earned more than did healthy participants, $U(27,15) = 105$, $p < .01$, and recovered participants, $U(15,12) = 45.5$, $p = .03$, though recovered and healthy participants exhibited no difference, $U(27,12) = 160$, $p = .96$ (see Figure 2, Panel A). Finding performance outliers (see Figure 2, Panel A), we repeated the analysis, excluding participants earning less than 25 points; these subsequent analyses yielded similar results. Consistent with these results, we found a significant positive relationship between BDI scores and performance, Kendall's $\tau(54) = .20$, $p = .05$. However, we interpret this with caution because within groups, correlations between BDI and search, or performance, were nonsignificant.

Decision Strategy

The performance differences in the secretary task may result from the decision strategies participants employed. To investigate this, we computationally modeled decisions with a multiple threshold strategy (Bearden et al., 2006; for details on the model and its implementation, see online supplementary material). This strategy extends the successful single threshold rule, proposed in the original secretary problem, to describe participants' behavior (e.g., Seale & Rapoport, 1997, 2000). The strategy's parameters indicate how long a participant would wait before he or she would accept a candidate that was the best, second best, etc., of the previously seen candidates. For example, if the first parameter is 10, the participant would not make a choice before seeing the first nine applicants but would accept, from Applicant 10 onward, the next applicant that exceeds the previously seen applicants. The parameters can be interpreted as capturing internal thresholds (THs) for accepting an applicant that is best, second best, and so on, in comparison with previously seen applicants. This decision strategy explained, on average, 65% ($SD = 17.21$) of participants' choices. Participants did not differ significantly on how well they were described by the strategy, $F(2, 51) = 1.57$, $p = .21$, or the third threshold, TH3: $F(2, 51) = 2.08$, $p = .14$, but they did differ on the first two thresholds (TH1, TH2, see Table 3 for means and standard deviations); TH1: $F(2, 51) = 3.90$, $p = .03$; TH2: $F(2, 51) = 3.53$, $p = .04$. Follow-up contrasts indicated that depressed participants' first and second threshold were significantly higher than the thresholds of healthy participants or recovered participants, though healthy participants did not differ from recovered participants (see Table 3). As illustrated by Figure 2 (Panel B), we found correlations between BDI scores and threshold values, TH1 $r(54) = .29$, $p = .03$; TH2 $r(54) = .33$, $p = .01$, but again, these correlations were not significant within groups. Comparing participants' parameters with parameters that would optimally solve the task showed that depressed participants had values closer to the optimal values than did healthy or recovered participants.

Table 2
Means, Medians, and Standard Deviations of Performance in the Secretary Problem

	Healthy			Recovered			Depressed		
Measure	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*
Search length	17.96	8.74	19	16.87	7.43	15.5	23.37	7.89	26.5
Relative rank	1.57	1.64	1.00	1.54	1.16	1.00	1.73	1.18	1.00
Performance	35.17	5.59	37.00	35.50	5.63	37.25	37.67	1.22	38.00
Goal	4.37	6.46	3.00	3.58	2.67	2.50	3.77	2.41	3.00

Note. Healthy $n = 27$; recovered $n = 12$; depressed $n = 15$.

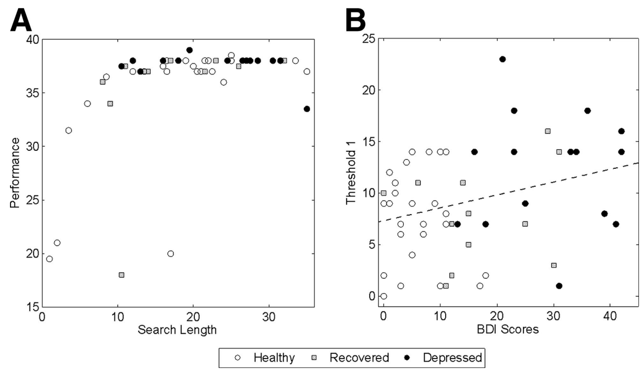

Figure 2. Panel A shows search length and performance in the three groups. Panel B shows the correlation between Beck Depression Inventory (BDI) score and the first threshold; the dotted line denotes the regression line, $r(54) = .29$, $p = .03$.

To ensure that the differences we found were not caused by some participants being poorly described by the strategy, we excluded seven participants for whom the strategy described less than 50% of the choices. A reanalysis in the restricted sample showed the same pattern of results as the full sample. The restricted sample also allowed us to conduct a mediation analysis to test whether differences in the parameters could explain differences in performance, since the performance scores in the restricted sample approximated a normal distribution. A hierarchical regression analysis, with dummy variables for the comparison between healthy and depressed versus healthy and recovered entered in the first step and the first threshold entered in the second step, showed that the significant effect of the depressed sample on performance ($b_{\text{depressed}} = 0.33$), $t(45) = 2.21$, $p = .03$, vanished if TH1 was included in the model ($b_{\text{depressed}} = 0.09$), $t(44) = 0.66$, $p = .51$. Instead, TH1 had a significant influence on performance ($b_{\text{TH1}} = 0.60$), $t(44) = 4.73$, $p < .001$, indicating that it mediated the influence of the depressed sample on performance (Sobel test = 2.40, $p = .02$).

Discussion

The relation between depression and cognitive functioning has sparked considerable debate. Although some studies reported deficits in cognitive processing among depressed individuals, others reported no differences or performance increases with depression (e.g., Andrews & Thompson, 2009; Hammar & Ardal, 2009). We present one of the first studies showing that clinically depressed individuals can outperform healthy individuals in a laboratory task: Performing a sequential decision task, clinically depressed individuals received higher payoffs than did (a) participants of similar age and education who were not depressed and (b) participants recovering from a depressive episode.

Our research suggests that sequential decision making may represent a class of problems in which depression leads to increased performance. Healthy participants perform below optimal levels in sequential choice tasks because their acceptance thresholds are too low (e.g., Seale & Rapoport, 1997). In our task, an analysis of the decision process suggested that depressed participants performed better because they had higher thresholds and accepted options less readily than did healthy individuals. In fact, the thresholds of depressed individuals more closely approximated the optimal policy, which suggests that depressed participants perceived option quality more accurately (see Alloy & Abramson, 1979; Strunk & Adler, 2009). Furthermore, sequential choice represents a relatively complex task requiring cognitive abilities (Burns et al., 2006). This suggests that our findings resonate with studies claiming that negative affect and the desire to increase control promotes analytical, systematic, and thorough information processing (e.g., Bless et al., 1990; Gleicher & Weary, 1991; for an overview see Andrews & Thomson, 2009), which may offset depression's negative effect on cognitive functioning.

However, although we found that depressed participants had higher thresholds than did nondepressed participants, we did not find significant differences in the self-reported goals of participants. This suggests that differences in behavior may not result from participants' conscious effort to perform well. Thus, increases in thresholds could be an artifact stemming from greater persistence and the inability to disengage from a task. However, this hypothesis cannot explain why depressed participants performed better because searching too much would decrease performance in the sequential choice task. Furthermore, Burns et al. (2006) showed that high performance in the secretary problem is correlated with intelligence, suggesting that performance benefits result from better reasoning.

Our study also offers insight into whether subclinical levels of depression can be compared with clinical depression. We found effects for participants still reporting clinical levels of depression

Table 3
Parameter Values of the Multiple Threshold Model

		Healthy		Recovered		Depressed		Contrasts healthy–depressed		Contrasts recovered–depressed		Contrasts healthy–recovered	
Threshold	Optimal values	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t*(51)	*p*	*t*(51)	*p*	*t*(51)	*p*
Threshold 1	12	8.08	4.74	7.92	4.70	12.27	5.66	2.60	.01	2.25	.02	0.09	.93
Threshold 2	20	11.30	5.60	11.00	6.19	15.87	5.79	2.45	.02	2.17	.04	0.15	.88
Threshold 3	26	15.59	7.42	14.42	8.40	19.53	5.26						
Fit		62.22	16.38	63.89	19.27	71.78	16.32						

Note. Healthy $n = 27$; recovered $n = 12$; depressed $n = 15$. For information on the higher thresholds, see online supplementary material.

but not for those participants who—although still reporting higher levels of depression than healthy individuals—showed indication of recovery. This suggests that—at least in sequential choice—only an acute and severe state of depression leads to changes in strategic behavior. This finding speaks against a u-shaped relation between performance and depression severity, though one should recognize that the recovery group in our study may differ from a subclinical sample. Participants in the recovery group were patients that had experienced clinical symptoms but were on the way to recovery, whereas subclinical samples consisted of overall healthy participants reporting high negative affect. Readers should keep in mind that roughly half the participants received medication that could have contributed to a change in depressive symptoms, as well as in cognitive processes (e.g., Gualtieri et al., 2006). Although depressed and recovered participants did not differ, on average, in terms of medication and length of stay, it could be that the recovered participants responded better to medication or might have received medication prior to hospitalization. Future research is necessary to replicate our results and disentangle the effects of recovery, subclinical levels of depression, and medication. A further limitation of our study is the relatively small sample size and the lack of a clinical control group. Though past research links analytical thinking and more realistic assessments of options to depression, we do not deny that other psychopathologies could show similar patterns of performance. Last, it needs to be mentioned that our diagnosis of MDD consisted of a single opinion. Future studies should investigate performance in clinical populations subject to multiple diagnoses with high interrater reliability.

Still, our findings offer new insight concerning depression and cognitive performance. We found that depression led individuals in a sequential decision-making task to set higher thresholds for acceptable options, and this led to better choices. This finding indicates that the effect of depression on cognitive functioning is complex and cannot be consistently associated with deficits in cognitive functioning.

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