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Cognitive functioning in young and middle-aged unmedicated out-patients with major depression: testing the effort and cognitive speed hypotheses

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ABSTRACT

Background. Cognitive deficits are common in major depressive disorder, but their nature is unclear. The effort hypothesis states that performance on effortful tasks is disproportionately impaired compared with the performance on automatic tasks. The cognitive speed hypothesis states that depression is characterized by cognitive slowness, which is a source of cognitive dysfunctioning. The present study investigated both theories in unmedicated adult depressive patients. It was also investigated whether the cognitive deficits can be attributed to more general physical illness-related factors or specifically to depressive disorder.

Method. Thirty non-psychotic depressive out-patients were compared with 38 healthy control subjects and 25 patients with severe allergic rhinitis. The effects of group on more automatic and more effortful aspects of cognitive tasks measuring cognitive speed (Concept Shifting Task, Stroop Colour Word Test, Memory Scanning Test) and memory retrieval (Visual Verbal Learning Task, Verbal Fluency Test) were evaluated by MANCOVA. Age, sex, education and pre-morbid intelligence were treated as covariates.

Results. The depressive group had cognitive deficits in the automatic processing subtask of the Stroop, memory scanning and memory span. Performance on more effortful tasks was not impaired.

Conclusions. Our results are more consistent with the cognitive speed hypothesis. Cognitive functioning in depressive disorder seems to be characterized by a reduced speed of information processing in automatic subtasks.

INTRODUCTION

Cognitive deficits are common in major depressive disorder. Most research has focused on older subjects with depressive disorder and these individuals generally perform worse than healthy controls on tests of information processing, such as psychomotor speed (Zakzanis *et al*. 1998; Nebes *et al*. 2000), memory (Burt *et al*. 1995; Austin *et al*. 2001), attention (Trichard *et al*. 1995; Lemelin & Baruch, 1998) and executive function (Veiel, 1997; Austin *et al*. 2001). It is still not clear whether a more general cognitive mechanism is responsible for the cognitive dysfunction in major depression. One hypothesis states that cognitive functioning is characterized by slowed information processing (Widlöcher, 1983; Nebes *et al*. 2000). Speed of information processing could be considered a resource for cognitive functioning (Kail & Salthouse, 1994; Salthouse, 1996) and therefore reduced cognitive speed may negatively affect

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higher cognitive functioning. In older depressive patients, several studies have provided support for this speed hypothesis of cognitive deficits (Feehan *et al.* 1991; Zakzanis *et al.* 1998; Nebes *et al.* 2000). However, since ageing itself is characterized by a slower speed of information processing (Sliwinski & Buschke, 1999), old age is a confounder of cognitive functioning in depression. It is therefore crucial to test this hypothesis in younger depressive patients. If problems in higher cognitive processing are not accompanied by speed problems, then this hypothesis would appear not to be valid.

The hypothesis concerning effortful or controlled processing (Hasher & Zacks, 1979; Ellis & Ashbrook, 1988) also provides an explanation for the cognitive deficits seen in depression. According to this hypothesis, depressive disorder is characterized by problems in allocating effort to cognitive tasks. Some tasks require more effortful processing, for example when they rely on elaborate processing activities such as rehearsal, imagery, organization, clustering, or systematic searching. This is in contrast with automatic processing, which involves skills that have been severely practised and are mastered in such a degree that they will not improve any further (Hasher & Zacks, 1979). These skills require minimal attention, and do minimally interfere with other ongoing mental activities. For example, the well-known Stroop-effect in adults proves that word reading is such an automatic process. According to the effort hypothesis, the performance of tasks that involve more mental effort is disproportionately impaired compared with the performance of tasks that depend on more automatic processing. Most support for this hypothesis has come from research on memory performance in older individuals (see for reviews Hartlage *et al.* 1993; Zakzanis *et al.* 1998; Austin *et al.* 2001).

Few studies have explicitly investigated the effort hypothesis for cognitive domains other than memory. In a meta-analysis of cognitive function in older individuals with major depression, Zakzanis *et al.* (1998) found that the performance of effort-demanding tasks could almost completely discriminate between major depressive patients and controls (especially tasks of encoding of information), while the performance of automatic tasks was not a reliable discriminator. Several studies have shown younger depressive patients to have a defect on effortful tasks of executive function and attention (e.g. Alexopoulos *et al.* 2000; Schatzberg *et al.* 2000; Murphy *et al.* 2001). However, very little information is available about automatic processing in cognitive domains other than memory in younger patients. To test the effort hypothesis in younger depressive patients, tasks that involve effortful processing should be compared with tasks that involve automatic processing. If problems in automatic information processing are present without accompanying disproportionately greater problems in effortful information processing, then this hypothesis would appear not to be valid.

It is important to determine the specificity of cognitive deficits for major depressive disorder, when studying mechanisms of cognitive functioning in major depressive disorder. Most studies have compared the cognitive functioning of depressive patients with that of healthy control subjects. However, healthy controls differ from depressive patients not only in the absence of psychiatric illness, but also in the absence of secondary disease-related aspects, for example the stress that accompanies not feeling well. This makes it difficult to determine whether cognitive deficits are caused by the depressive illness itself or by these more general disease-related aspects. Although a few studies have compared the cognitive performance of depressive patients with that of psychiatric control subjects (DeLuca *et al.* 1995; Fossati *et al.* 1999), to our knowledge no studies have been performed with a physically ill control group, which is necessary to investigate the role of more general disease-related aspects. In the present study we tested the cognitive speed hypothesis and the effort hypothesis as applied to several cognitive domains. A group of non-psychotic patients with major depression was compared with a healthy control group and a physically ill control group. The physically ill group consisted of patients with severe allergic rhinitis. Allergic rhinitis is a chronic disease of non-neurological origin, and possible effects on cognition are not expected to be caused by symptomatic allergic rhinitis itself, but merely by the secondary aspects of not feeling well. Allergic rhinitis has a considerable negative effect on quality of life (Juniper & Guyatt, 1991; Bousquet *et al.* 1994; Kremer *et al.* 2001), and patients – especially those with

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Table 1. *Descriptive data for age, education, sex, current IQ, vocabulary and depressive symptoms for all groups*

	Group			
	Depressive ($N=30$) Mean ± S.D.	Allergic ($N=25$) Mean ± S.D.	Healthy ($N=38$) Mean ± S.D.	Statistic test
Age	41·6 ± 12·4	39·9 ± 12·3	44·1 ± 11·2	$F_{(2,90)}=1{\cdot}01$
Female, (%)	(46·7)	(44·0)	(52·6)	$\chi^2=0{\cdot}50$
Education	3·3 ± 1·3	4·4 ± 1·2	4·0 ± 1·7	$F_{(2,90)}=4{\cdot}09$*
IQ	112·0 ± 10·5	114·2 ± 9·4	113·2 ± 9·9	$F_{(2,90)}=0{\cdot}35$
Vocabulary	12·5 ± 3·3	13·9 ± 2·7	13·4 ± 2·8	$F_{(2,90)}=1{\cdot}66$
BDI	24·6 ± 9·0	4·7 ± 2·8	4·2 ± 3·4	$F_{(2,90)}=125{\cdot}50$***

* $P<0{\cdot}05$; *** $P<0{\cdot}001$.

severe complaints – need to consult a specialist regularly. For subjects in all groups, special care was taken to include young to middle-aged adult subjects without any psychotropic medication to avoid the effects of these drugs on cognition. With this design, cognitive performance cannot be explained in terms of old age or medication.

With respect to cognitive functioning, we contrasted automatic information processing with controlled information processing by comparing the subjects' performance on subtasks involving these aspects. We used tasks that measure speed of information processing as well as tasks that measure non-speed related memory processes. Measures were chosen based on sensitivity to even mild impairments (Moller *et al.* 1998; Van Boxtel *et al.* 2000; Van der Werf *et al.* 2001). With regard to speed of information processing, we compared more automatic *versus* more controlled aspects of set shifting (speed of naming alphabet and numbers *versus* set shifting; Austin *et al.* 2001), response inhibition (speed of reading and colour naming *versus* interference; Besner & Stolz, 1999) and searching of working memory (automatic detection *versus* controlled search; Brand & Jolles, 1987). With regard to memory, we compared tasks that rely on more automatic emptying of information stored in memory span with tasks that require more controlled search and retrieval strategies (Hartlage *et al.* 1993; Crowe, 1998). These aspects are measured in verbal memory and search in semantic memory.

Three hypotheses were tested: (1) younger unmedicated depressive out-patients are characterized by cognitive deficits; (2) the pattern of cognitive functioning is either more consistent with the cognitive speed hypothesis or with the effort hypothesis; (3) cognitive deficits are specific for depressive disorder, and are not associated with more general disease-related aspects.

METHOD

Study design

In a cross-sectional design, a group of out-patients with major depression was compared with two control groups: an out-patient group with severe symptomatic allergic rhinitis; and, a healthy control group. The groups were matched for age, sex and pre-morbid IQ (see Table 1). The test protocol lasted approximately 1·5 to 2 h, including a short break and included several neuropsychological measures of intelligence, speed and memory, and self-report inventories. The protocol was reviewed and approved by the Medical Ethics Review Committee, the subjects gave informed consent. All subjects were paid €11·4 for participation and received a written report of their neuropsychological results.

Subjects

The depressive group included 30 unmedicated out-patients with moderate to severe major depressive disorder. Patients were attending the ambulatory service of a psychiatric hospital, which in the Netherlands represents a tertiary care facility. Major depressive disorder was diagnosed by a psychiatrist following DSM-IV criteria. Between 1999 and 2001, all out-patients who entered the psychiatric hospital and who did not use psychotropic medication were included in the present study and were assessed

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before medication was prescribed. Furthermore, patients in whom medication treatment was altered because of insufficient efficacy entered the study after a wash-out period of 2 weeks, or 3 weeks in the case of previous fluoxetine treatment. Twenty-three patients experienced a first-ever depressive episode, four patients had experienced one episode before and three patients experienced two or three episodes before the present episode. Symptom severity was measured using the Beck Depression Inventory (BDI) (Beck & Steer, 1993), a self-report measure for depressive symptoms. The BDI correlates highly ($r = 0{\cdot}73$) (Beck *et al.* 1988; Groth-Marnat, 1990) with the clinician-administrated Hamilton Depression Rating Scale (Hamilton, 1960). Subjects were aged 18–65 years; mean age was $41{\cdot}6 \pm 12{\cdot}4$ years; 46·7% was female and subjects had a mean IQ of $112{\cdot}0 \pm 10{\cdot}5$. Patients were moderately to severely depressed (mean BDI $24{\cdot}6 \pm 9{\cdot}0$) (see Table 1). Exclusion criteria were use of any psychotropic medication, other psychiatric disorders, neurological disorders, somatic disorders that affect cognitive function (e.g. diabetes, thyroid dysfunction), drug or alcohol abuse, dyslexia and colour blindness. No subject had received electroconvulsive therapy in the past. Depressive subjects were assessed in the psychiatric hospital.

The group with allergic rhinitis consisted of 25 out-patients from the Department of Otorhinolaryngology, Head and Neck Surgery. Patients with seasonal allergic rhinitis, allergic to grass- and/or tree-pollen, and patients with perennial allergic rhinitis, allergic to house dust mite, were included. Subjects were examined during a symptomatic period. Possible symptoms were nasal secretion, nasal blockage, itching and sneezing. Symptoms were rated on a four-point scale (absent, mild, moderate, and severe). All patients had a symptom score which was at least moderate for at least two symptoms, which is generally regarded to indicate severe symptoms of allergic rhinitis, and/or had a Rhinitis Quality of Life Questionnaire (RQLQ)-score (Juniper & Guyatt, 1991) that was >1. Other inclusion criteria were age between 18 and 65 years, a positive medical history of seasonal or perennial allergic rhinitis, anti-allergy treatment in a previous season, and a positive radio-allergosorbent-test (RAST) for serum-specific immunoglobulin E or a positive skin prick test for tree- and/or grass-pollen or for house dust mite allergens. Mean age was $39{\cdot}9 \pm 12{\cdot}3$ years; 44·0% was female and subjects had a mean IQ of $114{\cdot}2 \pm 9{\cdot}4$ (see Table 1). Exclusion criteria were use of psychotropic medication, a history of treatment for neurological or psychiatric disorder, drug or alcohol abuse, dyslexia, and colour blindness. Any anti-allergy treatment (e.g. nasal decongestants, anti-histaminics, anticholinergics, sympathomimetics, theophylline preparations) was ended before the assessment took place. Allergic subjects were assessed in the Department of Otorhinolaryngology, Head and Neck Surgery.

Thirty-eight healthy control subjects were selected from a large pool of healthy controls, collected for use in the Maastricht Aging Study (Jolles *et al.* 1995; Van Boxtel *et al.* 1998). Inclusion and exclusion criteria were the same as for the allergic patients, with the exception of the allergy requirement, which was an additional exclusion criterion in this group. Mean age was $44{\cdot}1 \pm 11{\cdot}2$ years; 52·6% was female and subjects had a mean IQ of $113{\cdot}2 \pm 9{\cdot}9$ (see Table 1). Healthy subjects were assessed in the same environment as the depressive group.

Measurements

Concept Shifting Task

As a measure of visuomotor tracking and set shifting, the Concept Shifting Task (CST) was used (Vink & Jolles, 1985). In part A, 25 consecutively numbered circles arranged in a larger circle, have to be crossed out as fast as possible. Part B is the same for letters. In part C the subject has to alternate between circles with numbers and letters (1–A–2–B–etc.). Part 0, in which the subject has to cross out empty circles, reflects the motor speed component. By subtracting part 0 from the other parts, a reliable estimate of the speed of cognitive processes can be made. Parts A and B minus part 0 both reflect cognitive speed for relatively automatic information processing, and these parts were combined into a mean value of cognitive speed (CST-automatic). Part C minus part 0 reflects speed of set shifting, which involves more effortful processing (Austin *et al.* 2001).

Stroop Colour Word Test

The Stroop Colour Word Test (SCWT; Stroop, 1935) is a measure of response inhibition. The

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test involves three cards displaying colour names printed in black ink (SCWT-1), coloured patches (SCWT-2), and colour names printed in incongruously coloured ink (SCWT-3). On the first and second cards, the coloured names and patches have to be read aloud as quickly as possible. On the third card, the amount of time needed to discard irrelevant but salient information (reading of colour name) in favour of a less obvious aspect (naming colour of ink) is recorded. Cards 1 and 2 both reflect the cognitive speed of relatively automatic information processing, and were combined into a mean value of cognitive speed (SCWT-automatic). Card 3 involves suppression of the dominant response, which involves more effortful processing (Besner & Stolz, 1999).

Paper and Pencil Memory Scanning Test

To study the search of working memory, the Paper and Pencil Memory Scanning Test (MST) (Brand & Jolles, 1987) was given to the subjects, which is based upon the Sternberg-paradigm (Sternberg, 1975). In this measure a set of one to four letters has to be memorized and crossed out as fast as possible on sheets containing matrices of letters. The extra time needed to complete a subtask with increasing working memory is a measure of the ease with which information is processed in working memory. In this study the subtask with one letter (more automatic detection) and the subtask with two specific letters in between other letters (more controlled search; Brand & Jolles, 1987) were used.

Verbal Fluency Test

To study verbal fluency a semantic Verbal Fluency Test (VFT; animals) was used. Subjects were asked to name as many animals as possible in 1 min and response is recorded. The findings of Granholm *et al.* (1998) and Crowe (1998) strongly suggested that of the Verbal Fluency Test the performance in the first 15 s represent more automatic processing. Healthy subjects produce most of the words in the first 15 s and clearly showed a smaller pupillary dilatation response during this period. The authors state that 'this pattern of results suggests that automatic spreading of semantic network activation reduced demand for controlled strategic search processes during semantic fluency in the first 15 s of word retrieval' (Granholm *et al.* 1998). The study of Crowe (1998) showed that there is a store of high-frequency words accessed during the first 15 s of the fluency tasks, and as this store becomes more exhausted, the production and the word frequency decreases. Both studies are in line with the notion that in the first 15 s of the fluency tasks, a more automatic process is executed. Therefore, in this study, the number of animals named in the first 15 s is used as a measure of more automatic retrieval of words stored in working memory, whereas the number of animals named in seconds 16–60 is used as a measure of more effortful searching and retrieval strategies.

Visual Verbal Learning Test

To assess memory storage and memory retrieval, the Visual Verbal Learning Test (VVLT) was used (Brand & Jolles, 1985). In this test, 15 words are sequentially shown on a computer screen and the subject is asked to recall as many words as possible. This procedure is repeated five times. After a distraction period of 20 min, delayed recall is measured. The first trial is used to assess memory span (Rabbitt *et al.* 1995), which is the amount of information that is retrieved from memory without elaborate processing activities such as rehearsal, i.e. the amount of information that is automatically retrieved from memory (Lezak, 1995). Retrieval after 20 min involves more effortful search and retrieval strategies, required for intentional learning.

Covariates

Age, sex, level of education, and estimated premorbid intelligence influence cognitive performance (Lezak, 1995) and were controlled for in the analyses. Educational level was indexed on an 8-point scale, ranging from unfinished primary school (1) to university degree (8) (CBS, 1985). Current IQ was measured using the Groninger Intelligence Test (Luteijn & van der Ploeg, 1983). This test yields results that are comparable to those of the Wechsler Adult Intelligence Scale (Wechsler, 1955). Pre-morbid intelligence was estimated using the subtest 'vocabulary' of the GIT.

Data reduction and statistical analysis

Prior to analysis, all variables were examined for missing values and outliers, using various

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SPSS programs. In the healthy control group, two scores for memory recognition were missing due to technical computer problems, and both values were replaced by the mean of the healthy control group. In each group, outliers were identified using z scores ($z > 3{\cdot}29$ or $z < -3{\cdot}29$, $P < 0{\cdot}001$) (Tabachnick & Fidell, 2001). There were no outliers in the depressive group and the allergic control group. In the healthy control group two outliers were replaced by the most extreme value within the normal distribution (Tabachnick & Fidell, 2001).

Differences in age, education, and current and pre-morbid IQ were measured using an analysis of variance (ANOVA), and difference in sex was measured using chi-square tests. To test the effort hypothesis, two separate MANCOVAs were computed to determine whether the independent variable (group) was related to the variables measuring automatic cognitive performance and to the variables measuring effortful cognitive performance, controlled for age, sex, education and pre-morbid IQ. All *post hoc* tests for group comparisons were adjusted with Scheffé's test. Two-tailed probabilities of $\leqslant 5\%$ were considered significant. Statistical tests were performed with SPSS for Windows version 9.0 (SPSS, Inc. Chicago).

RESULTS

Table 1 gives descriptive data for age, sex, education, current IQ, vocabulary scores and BDI scores for the depressive group, and the allergic and healthy control groups. The groups differed in education ($F_{(2,90)} = 4{\cdot}09$, $P = 0{\cdot}020$) and BDI scores ($F_{(2,90)} = 125{\cdot}50$, $P < 0{\cdot}001$). *Post hoc* tests with Scheffé's correction for multiple comparisons revealed that the depressive group was significantly less-well educated than the allergic control group. Further analyses were controlled for education. Not surprisingly, the depressive group had higher BDI scores than both control groups, which did not differ in depressive symptoms from each other. The depressive group ($24{\cdot}6 \pm 9{\cdot}0$) had BDI scores indicative of moderate to severe depression, whereas both control groups had depression scores that were in the normal range (Beck & Steer, 1993; Rabbitt *et al.* 1995). Table 2 shows mean scores and standard deviations of the cognitive performance for the three groups.

Table 2. *Cognitive performance for groups: mean scores ± standard deviations*

Task	Performance measure	Group		
		Depressed	Allergic	Healthy
CST (s)	Automatic[a]	$15{\cdot}7 \pm 6{\cdot}4$	$12{\cdot}9 \pm 4{\cdot}0$	$13{\cdot}5 \pm 4{\cdot}1$
	Set shifting[b]	$26{\cdot}2 \pm 11{\cdot}3$	$21{\cdot}0 \pm 7{\cdot}4$	$22{\cdot}4 \pm 7{\cdot}0$
SCWT (s)	Automatic[c]	$55{\cdot}6 \pm 11{\cdot}0$	$48{\cdot}4 \pm 8{\cdot}0$	$49{\cdot}1 \pm 7{\cdot}9$
	Interference[d]	$93{\cdot}8 \pm 22{\cdot}3$	$81{\cdot}0 \pm 17{\cdot}9$	$83{\cdot}8 \pm 13{\cdot}8$
MST (s)	Set size 1	$35{\cdot}1 \pm 11{\cdot}0$	$29{\cdot}0 \pm 7{\cdot}0$	$30{\cdot}3 \pm 6{\cdot}6$
	Set size 2	$53{\cdot}0 \pm 16{\cdot}5$	$43{\cdot}9 \pm 13{\cdot}6$	$46{\cdot}8 \pm 10{\cdot}4$
VVLT (*N*)	Memory span[e]	$4{\cdot}5 \pm 1{\cdot}6$	$5{\cdot}1 \pm 1{\cdot}8$	$5{\cdot}6 \pm 1{\cdot}8$
	Retrieval	$8{\cdot}5 \pm 2{\cdot}7$	$9{\cdot}2 \pm 2{\cdot}9$	$9{\cdot}7 \pm 2{\cdot}6$
VFT (*N*)	1–15 s	$10{\cdot}4 \pm 2{\cdot}5$	$10{\cdot}6 \pm 2{\cdot}5$	$11{\cdot}1 \pm 2{\cdot}9$
	16–60 s	$12{\cdot}7 \pm 4{\cdot}6$	$14{\cdot}2 \pm 4{\cdot}5$	$14{\cdot}8 \pm 4{\cdot}5$

CST, Concept Shifting Task; SCWT, Stroop Colour Word Test; MST, Memory Scanning Test; VVLT, Visual Verbal Learning Test (number of Words); VFT, Verbal Fluency Test (number of animals).
[a] Mean of parts A and B minus part 0.
[b] Part C minus part 0.
[c] Mean of cards A and B.
[d] Card C.
[e] First trial.

To test the effort hypothesis, and thus to determine whether group had an effect on automatic as well as effortful cognitive processes, two separate MANCOVAs were computed. The first MANCOVA had group as independent variable and automatic subtests of cognitive variables (CST-automatic, SCWT-automatic, MST-1, VVLT-memory span and the first 15 s of the VFT) as dependent variable, with covariates age, sex, education and pre-morbid intelligence. Results of this test showed a significant omnibus effect ($F_{(10,164)} = 1{\cdot}89$, $P = 0{\cdot}05$) of group on automatic cognitive tasks. Univariate tests showed an effect on SCWT-automatic ($F_{(2,86)} = 3{\cdot}77$, $P = 0{\cdot}027$), MST-1 ($F_{(2,86)} = 3{\cdot}60$, $P = 0{\cdot}031$) and VVLT memory span ($F_{(2,86)} = 3{\cdot}74$, $P = 0{\cdot}028$). *Post hoc* univariate analysis adjusted with Scheffé's correction showed that for SCWT-automatic, the depressive group had a poorer performance compared with both control groups, which did not differ from each other. For MST-1, the depressed group had a poorer performance compared with the allergic group, and both control groups did not differ from each other. On the VVLT memory span, the depressed group performed poorer than the healthy control group, and both control groups did not differ significantly from each other.

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The second MANCOVA had group as independent variable and effortful subtests of cognitive variables (CST-set shifting, SCWT-interference, MST-2, VVLT-delayed recall and for 16–60 s of the VFT) as dependent variable, with covariates age, sex, education and premorbid intelligence. No significant omnibus effect of group on effortful cognitive tasks was present ($F_{(10,164)}=0{\cdot}88$, $P=0{\cdot}287$). This result indicates that the three groups did not differ from each other on cognitive tasks relying on effortful processing.

DISCUSSION

In this study, three hypotheses were posted: younger to middle-aged unmedicated depressive outpatients are characterized by cognitive deficits; the pattern of cognitive functioning is more consistent with the cognitive speed hypothesis, or with the effort hypothesis; and cognitive deficits are specific for depressive disorder. To this end, the performance of a group of non-psychotic out-patients with major depressive disorder was compared with that of a physically ill control group and a healthy control group on more automatic and more effortful information processing tasks. All groups consisted of adults not using psychotropic medication. Analyses were controlled for age, sex, education and premorbid intelligence.

Concerning cognitive functioning, the depressive patients in this study had an impaired performance on subtasks of response inhibition (SCWT), searching of working memory (MST) and verbal memory (VVLT) compared with both control groups. Indeed, these deficits seemed specific for the depressive group, because neither control group showed any cognitive deficits. The results suggest that cognitive deficits may be specifically attributed to depressive disorder and cannot be fully ascribed to more general physical disease-related factors (for example, stress, not feeling well) that are also present in patients with severe chronic allergic rhinitis.

Regarding the pattern of cognitive dysfunction, we distinguished between more automatic and more effortful information processing and between speeded and non-speeded measures. The construct of automatic processing was operationalized using subtasks that are, according to the literature, considered to involve automatic information processing in adults (Hasher & Zacks, 1979; Brand & Jolles, 1987; Hartlage *et al*. 1993; Crowe, 1998; Granholm *et al*. 1998; Besner & Stolz, 1999; Austin *et al*. 2001): reading, colour naming, simple ordering of numbers, alphabet naming, detecting one specific letter between other letters and retrieving information stored in memory span. For the operationalization of the construct of effortful processing, we used subtasks requiring elaborate processing activities: set shifting, interference and strategic searching of memory.

The depressive patients only had a poorer performance on some subtasks involving more automatic information processing (SCWT-automatic, MST-1 and VVLT memory span). They performed as well as both control groups on subtasks requiring effortful processing. These results do not support the effort hypothesis. Possibly, additional factors that were carefully excluded in this study (such as older age, medication, and psychotic symptoms) might explain the results of studies that favour the effort hypothesis.

The results are more in line with the cognitive speed hypothesis. The performance of the depressive group was fairly characterized by slowed information processing. The cognitive speed hypothesis would not have been valid when higher cognitive processes were not accompanied by speed problems. However, in our study depressive patients did not show deficits on higher cognitive processes (like interference, set shifting, memory retrieval). The results suggest that in young to middle-aged unmedicated depressive out-patients, cognitive deficits could be characterized by cognitive slowness, but only in more automatic subtests. Interestingly, in the field of cognitive ageing research, Salthouse and others (Kail & Salthouse, 1994; Salthouse, 1996) argued that the speed of information processing should be considered a resource for cognitive functioning. According to these authors, a slower speed of information processing may affect higher information processing, for example because the end products of basic processing are sometimes no longer accessible when they are needed for higher cognitive processing. Our results are in line with a cognitive resource problem in major depressive disorder. It is possible that younger out-patients are more able to compensate for slower cognitive speed

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than older patients, or more severely depressed in-patients. This would explain why deficits of higher cognitive functioning over and above decreased cognitive speed are found in older or in more severely depressive individuals (Burt *et al*. 1995; Veiel, 1997; Lemelin & Baruch, 1998; Schatzberg *et al*. 2000; Austin *et al*. 2001).

The results of this study are in line with several studies in depressive disorder, which show deficits in higher cognitive function accompanied with slower cognitive speed (Beats *et al*. 1996; Paradiso *et al*. 1997; Dietrich *et al*. 2000; Nebes *et al*. 2000). Tsourtos *et al*. (2002) and Grant *et al*. (2001) both performed a study in unmedicated younger depressive patients. The findings of Tsourtos *et al*. resemble the findings from the present study: using a very elegant measure to separate motor speed from cognitive speed, their results showed an impairment in cognitive speed. Grant *et al*. (2001) found a deficit in one measure of executive function (Wisconsin Card Sorting Test), without accompanying deficits in several other and comparable measures of executive function. No deficits in digit span, attention, memory, other executive function, and importantly, psychomotor speed were found, which is in contrast with our findings. Purcell *et al*. (1997), who studied 20 younger depressive out-patients, of which 12 received antidepressant medication, may have found deficits in higher cognitive function without slower cognitive speed. In their study, no deficits were found in short-term memory capacity, spatial working memory, planning ability, delayed matching to sample, recognition memory and thinking times or initial movement times on the Tower of London test. Depressed subjects were impaired on attentional set shifting and they were slower to complete the sequence of single moves on subsequent trials on the Tower of London test. Therefore, the findings of Grant *et al*. (2001) and Purcell *et al*. (1997) may be in agreement that executive dysfunction is present in depression, indicating specific deficits in effortful processing, in contrast to the findings of our study.

In summary, this study showed that deficits in several cognitive domains are present in unmedicated adult depressive out-patients. In this study, the deficits were specifically attributable to major depressive disorder and were not only caused by more general physical disease-related factors that would also be present in individuals with severe allergic rhinitis. The results are not in line with the effort hypothesis in major depression, since performance on subtasks that require effortful processing was not impaired. Results are more in line with the cognitive speed hypothesis, by which depressive disorder is characterized by a reduction in cognitive resources. Reduced speed of information processing may be the central cognitive deficit in major depressive disorder, and slowness in cognitive speed can be a general limiting factor for higher cognitive functioning, like memory retrieval, or executive functioning. Future cognitive research in depression should pay more attention to the possibility of cognitive speed as a general factor limiting higher cognitive functioning.

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