Eur Arch Psychiatry Clin Neurosci (1999) 249 : 79–85

ORIGINAL PAPER

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Attentional resources in major depression

Received: 23 March 1998 / Accepted: 19 November 1998

Abstract Depression appears to interfere more with effortful processes than with automatic processes.

This study aimed to examine attentional resources allocation by means of RT on effortful detection tasks. Ten depressed inpatients during illness and at recovery and ten healthy control subjects were given simple and choice reaction time tasks. Two types of effort demanding conditions were assessed (1) the combination of two concurrent tasks and (2) tasks involving decision making.

Depressed patients improved from single to dual tasks whereas recovered and control worsened. Depressed patients showed a significant time and accuracy impairment when decision processes were involved. The decision making impairment co-occurred with a deficit in the orientation of the attention. The decline with decision making was not worsened when the choice task combined with a concurrent task and was reversible with recovery.

This pattern of results exhibits differential sensitivity between two effortful tasks. Depressives may be able to mobilize resources to complete effortful tasks as far as decision processing is not required.

Key words Attention · Decision · Depression · Reaction time · Resources allocation

Introduction

Despite clinical evidence of attention impairment in patients with depressive illness, only a few studies have investigated attentional processes in mood disorders with respect to the theoretical frameworks provided by the advances of cognitive psychology. Most research on cognitive processing by depressive subjects has concluded that depression interferes more with effortful processes than with automatic processes (Hartlage et al. 1993). Reduced cognitive capacity (Hasher and Zacks 1979, Hasher et al. 1985), narrowing of attentional focus (Payne and Hewlett 1960, Ingram and Wisnicki, 1991), and capacity reduced, negative focus (Ellis and Ashbrook 1988) have been discussed as possible mechanisms for interference in effortful processes by depression.

The distinction between automatic and effortful processing has been established by several authors (La Berge 1973, Posner and Snyder1975, and Schneider and Shiffrin 1977). Automatic processes take place without requiring attention or conscious awareness. They do not interfere with other operations or stress the capacity limitations of the cognitive system. On the other hand, controlled processes – or effortful processes, conscious strategies or serial processes as they are alternatively named – require attention and thereby take place serially, inhibit other pathways, and are influenced by cognitive capacity-limitation. Evidence for the processing capacity limitation has led to the assumption that the source of limitation is attention itself (Broadbent 1958, Baddeley 1986, Posner and Petersen 1990). The central executive proposed by Baddeley (1990) or the supervisory attentional of Norman and Shallice (1988), which are assumed to be similar in function, may be involved in allocating attentional resources to components of executive control.

Effortful processing in depression has been examined through several paradigms, intellectual functioning (Clark et al. 1985, Robertson and Taylor 1985), problem solving (Braff and Beck 1974) and memory (Weingartner et al. 1981, Cohen et al. 1982, Calev and Erwin 1985, Roy-Byrne et al. 1986, Williams et al. 1987, Golinkow and Sweeney 1989). A majority have reported consistent evidence suggesting that interferences with these components occur depending on the degree of effortfulness of the task. However, there have been few systematic exami-

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nations of the attentional demand required by those experimental tasks. Studies using complex tests which explore intellectual functioning or problem solving demonstrate an overall attentional deficit without analyzing its components (Miallet 1996). All those paradigms involve effortful subskills, for example, decision making, which is supposed to be markedly impaired in depression (Widlöcher and Hardy-Bayle 1989). Thus, it remains unclear whether it is the function related to the whole task or some subskills that failed.

According to Schneider (1984), all tasks are accomplished with a mixture of both automatic and effortful processes. Moreover, a continuum of automatic through effortful processes has been suggested by several theorists (Kahnemann and Chajczyk 1983, Logan 1985, MacLeod and Dunbar 1988, Shiffrin 1988). Thus, interference in cognitive processes may depend on the nature of the subskills involved with the task. Reaction time (RT) paradigms are easily operationalized for experimentation. RT has been used to assess attention and its components in brain-damaged patients (Posner and Rafal 1987, Godefroy et al. 1996), whereas RT studies in depressive patients have focused mainly on general slowing (Hall and Stride 1954, Martin and Rees 1966, Byrne 1976, Weckowicz et al. 1978, Ghozlan and Widlöcher 1988, Schwartz et al. 1989).

The measurement of repeated RT might be more sensitive than general performance level measures (Milner 1986, Crabtree and Antrim 1988). RT method allows the analysis of the components of attention as a function of the task difficulty, by mean of progressive changes in the complexity or the response characteristics. Therefore, different effortful processes can be assessed with comparison of reaction time to task with various types of load (Godefroy et al. 1996b).

This study aimed to evaluate attention processing, by means of RT on detection tasks, as a function of the task difficulty in depressed patients before treatment and later when they had recovered, but still continued their treatment, with comparison to controls. Two types of effort demanding conditions were assessed: (1) the combination of two concurrent tasks and (2) a task involving decision making.

RT lengthening with depressive patients compared with controls should be consistent with the depression hypothesis of an overall reduction in resources allocation, otherwise a dissociation between these two conditions would suggest a task specific impairment in resource allocation.

Methods

Subjects

Ten patients, who were hospitalized in the Psychiatry Department of the University Hospital of Lille (France) and who fulfilled the diagnosis of major unipolar depression, agreed to participate in the study after giving their informed consent. Details of the patient groups are shown in Table 1. They were selected out of 38 patients referred to the study by co-operating psychiatrists. The French version of the Schedule for Affective Disorders and Schizophrenia (SADS) (Spitzer and Endicott 1979) was used to make sure the inclusion criteria were fulfilled: (1) a single or recurrent major depressive episode according to the DSMIII-R criteria (American Psychiatric Association 1987) and (2) a score between 20 and 45 on the Montgomery and Asberg Depression Rating Scale (MADRS) (Montgomery and Asberg, 1979). The exclusion criteria were: (1) other DSMIII-R axis I disorders of organic mental illness, substance abuse, schizo-affective disorders or schizophrenia. The controls were 10 members of staff from the hospital, without previous experience of chronometric assessment techniques, who were matched with the patients for their sex. Educational level was based on the total number of years they had spent at school. The controls had a MADRS score of less than 12. Both groups consisted of 9 right-handed and 1 left-handed individuals. After inclusion in the study, the patients were given a wash-out period of at least 5 days before participating in the first test session. After the first session, the patients were placed on non-tricyclic antidepressants (AD) (fluoxetine 20 mg n = 4, fluvoxamine 150 mg n = 3, or mianserin 60 mg n = 3) without addition of any benzodiazepines. A second session was performed when the patients had recovered from their depression, while still continuing their AD treatment; recovery was confirmed by a MADRS score < 12. The mean time between inclusion into the study and the second session was 48.6 days, SD = 23.

Table 1 Subjects' characteristics

	Depressed patients n = 10	Recovered patients n = 10	Controls n = 10
Gender M/F	4/6	4/6	4/6
Age: Mean (SD)	35 (8)	35 (8)	32 (9)
MADRS: Mean (SD)	36 (9)	8 (3)	5 (2)
Educational level	13 (2)	13 (2)	12 (2)

Educational level was based on the total number of years spent at school
Mean interval between sessions, from depressed to remitted state: 48.6 days, SD: 23

Tests and apparatus

The attention was assessed with bimodal RT sessions during which the ability to regulate attention between different sensory modalities was investigated. The subjects responded to visual or auditory targets generated by a Macintosh Classic Apple computer. The visual stimulus was a 2 × 2 cm black square which appeared for 100 ms on a 5 × 5 cm white background, displayed at the center of a black 18 × 13 cm monitor that was placed 70 cm from the subject. The auditory stimulus was a tone sound (100 Hz). The interstimulus interval (ISI) was variable (1, 2, 4, and 8). The tests were characterized by a combination of auditory (n = 40) and visual (n = 40) stimuli delivered in a pseudorandom fashion with 4 × 20 random presentation of the ISI. In all of the blocks of trial, an ipsimodal situation occurred when the preceding stimulus was of the same modality (visual-visual or auditory-auditory) and a crossmodal situation was when the preceding stimulus was of the other modality (visual-, auditory, or auditory-visual) (Fig. 1). Ipsimodal and crossmodal situations were equally distributed.

RT were measured under four conditions (i) simple bimodal RT (SBM): subjects had to respond to 80 stimuli regardless of the modality. This condition provided baseline RT. (ii) Choice bimodal RT (CBM): subjects had to respond to 80 stimuli with two types of responses depending on modality of the stimulus. (iii) To assess the dual task condition, both SBM and CBM test were repeated with an additional task that consisted in counting visual and auditory targets while performing. SBMd was the dual task with simple RT and CBMd was the dual task with choice RT. The sub-

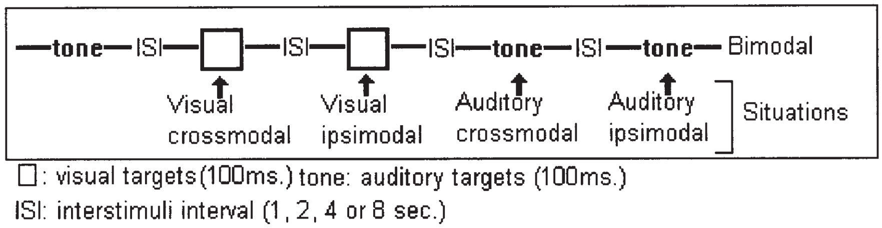


Fig. 1 Description of the stimulus situation in a sequence of the blocks of trials

jects were told to respond as quickly and as accurately as possible by pressing one single button in the SBM and SBMd and one of the two available buttons in the CBM and CBMd trials.

The two available right and left response buttons, 2 cm apart, were pressed with two fingers. The nature of the stimuli did not differ between the SBM, SBMd, CBM, and CBMd. The only difference was that the blue button had to be pressed for the visual stimuli and the red button for the auditory stimuli.

The RT was a dependent variable, which measured the time between appearance of the stimuli and the microswitch being pressed using software. Response times less than 100 ms were considered as anticipated responses and were rejected from the analysis; the time-limit for a response was fixed at 2 s.

Procedure

The patients took part in two sessions. The first was before antidepressant treatment had been started and the second when patients had recovered from their depression but still continued their treatment. The controls only participated in one session. A session consisted of four assessments lasting for one hour between 10 a.m. and 11 a.m. in a dark silent room. The instructions were read aloud by the examiner at the beginning of each test. A pre-test of 20 trials was performed prior to single but not double tasks. The tests were separated from each other by a time interval of 5 minutes. The sequence of the tests is shown in Fig. 2.

Stastistical analysis

Statistical analysis was performed using SPSS statistical software. In order to assess the extent of the response delay induced by changing the task, a group comparison study was made using repeated measures analyses of variance (ANOVAs) with the RT being the dependent variable. Between subject analysis were realized separately, (1) patients in the depressed state and (2) patients in the recovered state compared with controls, then (3) a subject comparisons of patients' RT in the depressed state and in the recovered state. The within subject variance was analyzed using ANOVA for five factors; modality (visual and auditory), situation (ipsimodal and crossmodal), response (simple and choice), task (single and double), and ISI (1, 2, 4, or 8 s.).

An other analysis was used to assess the extent of accuracy in choice tasks with the error rate being the dependent variable. Only p values ≤ 0.05 were considered as significant.

Results

Between subject analysis revealed significant differences in RT between (1) patients in the depressed state compared with controls (d.f.: 1, 78, F = 55.74. P < 0.001), (2) patients in the recovered state compared with controls (d.f.: 1, 78, F = 5.90, P < 0.017), and (3) patients in the depressed state and the recovered state (d.f.: 1, 78, F = 39.76, P < 0.001). These results indicated that patients in the depressed state took longer than controls, and they became faster with recovery; however while recovered, they remained longer than controls (see Table 2). The main effects of factor modality (d.f.: 1, 117 F = 74.63, P < 0.001), factor situation (d.f.: 1, F = 44.62, P < 0.001), factor response (d.f.: 1,117 F = 1250.99, P < 0.001), and factor task (d.f.: 1,117 F = 154,12, *P* < 0.001) were significant. There was no significant effect of the ISI factor. Thus, regardless of the diagnostic group the overall results indicated that visual RT were longer than auditory RT, crossmodal RT were longer than ipsimodal RT, choice RT were longer than simple RT, and dual task RT were longer than single task RT. This was consistent with most RT studies results.

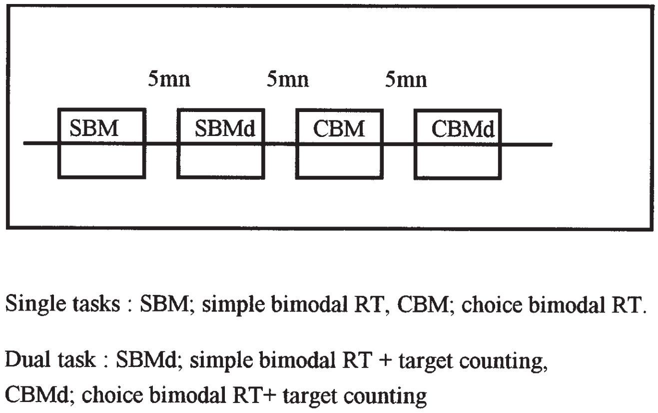


Fig. 2 Sequence of the tests figuring in the session

Effect of the decision

Patients' reactions in the depressed state were significantly more lengthened from simple to choice RT (time increment from SBM to CBM) than controls (subject × response interaction, d.f.: 1, 78, F = 194.64, P < 0.001). When recovered, patients' reactions remained more lengthened from SBM to CBM than controls (subject × response interaction, d.f.: 1, 78, F = 8.71, P < 0.004) but were significantly shorter than when depressed (subject × response interaction, d.f.: 1, 78, F = 53.26, P < 0.001) (Fig. 3).

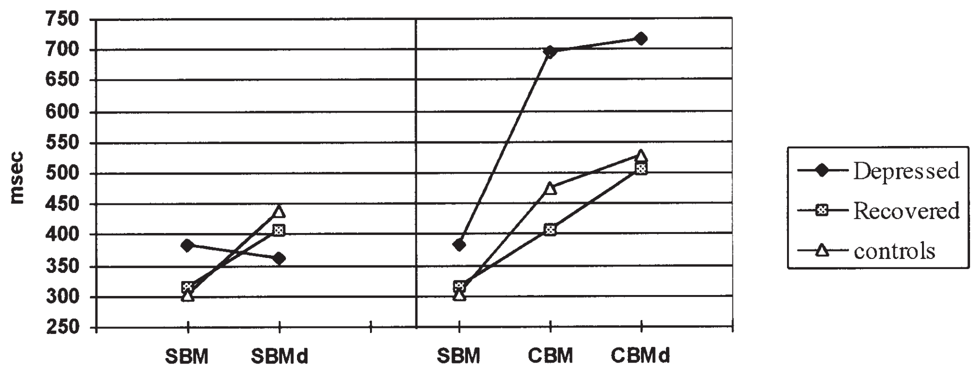
Effect of dual task

Patients' reactions in the depressed state were significantly less lengthened from single to dual task than controls with 5% versus 25% RT increase (subject × task in-

Table 2 Reaction time according to modality and situation; mean (± SD) values

	Depressed Mean (S.D.)	Rocovered Mean (S.D.)	Controls Mean (S.D.)
	SBM/SBMd	SBM/SBMd	SBM/SBMd
Auditory; ipsi	367 (61) / 318 (71)	301 (47) / 391 (69)	284 (95) / 436 (35)
; cross	384 (69) / 364 (100)	306 (45) / 395 (72)	293 (23) / 428 (36)
Visual; ipsi	390 (90) / 388 (87)	322 (33) / 421 (55)	310 (23) / 445 (37)
; cross	380 (64) / 371 (91)	329 (36) / 420 (63)	317 (18) / 448 (35)
	CBM/CBMd	CMB/CBMd	CBM/CBMd
Auditory; ipsi	563 (83) / 644 (248)	461 (64) / 498 (79)	434 (37) / 477 (31)
; cross	672 (147) / 752 (252)	503 (69) / 557 (97)	475 (50) / 515 (45)
Visual; ipsi	613 (131) / 628 (214)	515 (90) / 574 (81)	479 (45) / 547 (53)
; cross	681 (174) / 735 (204)	543 (93) / 608 (51)	507 (46) / 578 (71)
Error rate	76% (52) / 73% (48)	23% (21) / 20% (17)	17% (13) / 18% (15)

Single tasks: SBM; simple bimodal RT, CBM; choice bimodal RT;
Dual task: SBMd; simple bimodal RT + target counting, CBMd; choice bimodal RT + target counting



Single tasks : SBM; simple bimodal RT, CBM; choice bimodal RT.

Dual task : SBMd; simple bimodal RT + target counting, CBMd; choice bimodal RT+ target counting

Fig. 3 Change in mean reaction times from simple (SBM to dual (SBMd) conditions and choice (CBM) to mixed (CBMd) conditions

teraction, d.f.: 1, 78, F = 34.22, P < 0.001). When recovered, patients' reactions were less lengthened (18% RT increase) from single to dual task than controls (subject × response interaction, d.f.: 1, 78, F = 11.87, P < 0.001) but more lengthened than when depressed (subject × response interaction, d.f.: 1, 78, F = 12.91, P < 0.001).

The type of the response had a significantly different effect on patients and controls as confirmed by the significant subject × response × task interaction through the 3 group by group analysis. Controls' reactions were more lengthened from SBM to SBMd than from CBM to CBMd. This pattern made them different from patients in the depressed state whose RT significantly decreased from SBM to SBMd whereas there was no significant difference in RT from CBM to CBMd (subject × response × task interaction, d.f.: 1, 78, F = 46.56, P < 0.001). On the other hand, patients' reactions in the recovered state were less lengthened than controls from SBM to SBMd but more lengthened from CBM to CBMd (subject × response × task interaction, d.f.: 1, 78, F = 15.86, P < 0.001). With recovery, patients' reactions became significantly longer in performing dual task, with a significantly greater impairment in simple than in choice response trials (subject × response × task interaction, d.f.: 1, 78, F = 20.80, P < 0.001).

Crossmodal effect

Patients in the depressed state showed a significantly higher crossmodal retardation than controls (subject × situation interaction, d.f.: 1, 78 F = 7.16, P < 0.009). The interaction effect of factor subject × factor situation × factor task was not significant, suggesting that the crossmodal retardation due to the dual task was not different with patients in the depressed group compared with controls. The crossmodal retardation was significantly higher in patients when depressed than when recovered (subject × situation interaction, d.f.: 1, 78 F = 5.57, P < 0.021). Patients in the recovered group did not show significantly more crossmodal retardation when compared to controls.

In summary, the RT of depressed patients significantly increased in the choice condition which reflects an impairment due to the involvement of the decision processes. Furthermore, there was a dissociation of the crossmodal effect in depressed that occurred in choice but not in dual task condition.

Accuracy

The error rates for choice response conditions (Table 2) were compared using a between subject analysis of variance for one factor: task (single and dual). Patients in the depressed state exhibited a significantly higher rate of error (mean 74%) than controls (mean 18%), (d.f.: 1, 78 F = 7.19, P = 0.008) and than following recovery (mean 22%), (d.f.: 1, 78 F = 6.07, P = 0.015). There was no significant difference between patients in the recovered state and controls. However, depressed patients did not show any significant increase in error rate from CBM to CBMd conditions. These results show that the accuracy in choice condition was impaired in depressed patients, reversible with remission, and was not sensitive to dual task condition.

Discussion

On the overall RT results, this group comparison experiment showed that depressed patients' reactions are longer than following recovery and than controls. However, their sensitivity to two types of effort demanding tasks was dissociated. Depressed patients showed an improvement of time while performing the combination of two concurrent tasks, whereas they worsened following recovery as well as controls. On the other hand, depressed patients showed a significant time and accuracy impairment when decision processes were involved in the task. The decision making impairment co-occurred with a deficit in the orientation of the attention as shown by the cross modal retardation effect during the choice RT tasks. Moreover, the decline with decision making was not worsened when the choice task was combined with a concurrent task and was reversible with recovery. These results taken together suggest that depression does not interfere identically with all effortful processes but depends of the nature of the task, especially with tasks involving decision processing.

Controls were not psychiatrically ill, and not hospitalized subjects; thus, it may be argued that hospitalization effect may increase differences in performances. However, Tancer et al. (1989) have reported that effortful cognitive deficits in major depression was not simply a function of hospitalization. The tests used in this study were simple and choice response tasks, easily administered to depressive patients. In order to avoid the possible bias that would occur on tasks with a high degree of difficulty, we used tests which did not require spatial attention. Testing has been carried out in a fixed order of successive changes in complexity and response type across all subjects. Thus, fatigue and practice effects may have interfered with results. To our knowledge there are no published RT studies focusing on fatigue and practice effect in depressive disorders. However, the dissociated results we observed may not be explained in totality by these effects. A possible explanation of the improvement of depressed patients from simple to dual task is that the depressed patients may have been more sensitive to a practise effect. It has been reported that normal individuals, who respond more slowly to the initial runs of trials with RT tasks, show significantly greater improvement as a result of practice than those who respond more quickly (Rabbitt 1993). Thus, untreated depressed patients may take some time to accustom themselves to an unfamiliar experimental situation, as it has been reported in old or frail patients and those who perform less well on intelligence tests (Rabbitt and Goward 1994).

During the simple RT tests (SBM and SBMd) subjects had to exert the same response to each stimulus regardless of its modality. The motor response remained exactly the same. Therefore, the higher demand on attentional resources, required by target counting, may account for RT change. The combination of the two concurrent tasks placed a load on attention processes with increasing resource demand. According to the model which postulates reduced attentional resources in depression (Hasher and Zacks 1979), it was predicted that depressed subjects would show an impairment as a function of task demand on attentional resource. In the present study, as expected, the RT of the control subjects increased, but the RT of the depressed patients decreased from single to dual task. Such an improvement attests that depressed patients are able to allocate resources required by this type of task. Similar paradoxical findings have been reported by Krames and McDonald (1985), who observed the performance of depressed patients to be improved when the cognitive load was increased by means of a double task, whereas they had performed poorly with a single task. In the same way, Hertel and Rude (1991) reported comparable performances between controls and depressed patients for a task which required effort from attention. Consistent with our results, these two experiments showed the performance of depressed patients to be comparable to that of normal subjects, when they took part in tasks which required more effort. This could be explained by mobilization of processing resources that was stimulated by the cognitive effort demanded by the procedure. This result is not consistent with a general slowing hypothesis or reduced cognitive capacity, otherwise depressed patients' reactions would have been more lengthened while performing the dual task. A motivational deficit, as it has been proposed by MacAllister (1981) appears also unlikely for the same reasons. This resource availability within depressives is consistent with Ellis and Ashbrook (1988) who proposed the narrowing of attention to focus primarily on task irrelevant thoughts or on specifically depression relevant thoughts. According to this model, it might be argued that depressed patients are able to mobilize resources previously captured by other interfering uncontrolled processes in order to complete more effortful conditions such as dual task. The reduction of depressed patients RT from baseline to dual task condition may account for the amount of the resources previously allocated to other uncontrolled processes.

The choice task placed a load on attention processes by involving decision processing. Decision making resulted in a time increment as well as a poorer accuracy and a marked crossmodal effect in depressed patients compared with medicated and recovered patients and controls. Change in the modalities induced a shifting of attention between the perceptual channels (LaBerg 1973, Rist and Thurm 1984). Further changes in the crossmodal RT may be related to the shift of attention from one channel to the other. The lengthening of crossmodal compared to ipsimodal RT is likely to be due to the time required to shift attention, therefore, related to the ability in orienting attention. However, recovered patients who spent more time to shift than controls were nearly as accurate as controls. LaBerge (1973) showed that interchannel shifting has to be completed before activation of the motor response occurs. Thus the increment of time required to shift attention from one modality to another might be insufficient in depressed patients to obtain accurate response. This suggests that, with recovery, required resources to complete decision are available, but with a cost of time to complete shifting. Therefore, time lengthening may not be sufficient in depressed patients to obtain accuracy conversely with recovered and medicated patients. These findings strongly suggest that depressed patients show an impairment in dividing and orienting attention on different sensory channels when the decision processes are involved.

A failure of decision processing has been reported in frontals (Godefroy and Rousseaux 1996a). PET activation studies found that selection among competing responses was mediated by cingulate regions (Pardo et al. 1991, Bench et al. 1993) or rostral prefrontal area (Baker et al. 1996). Bench et al. (1995) have reported a pattern of regional cerebral blood flow (rCBF) from the depressed to the recovered state involving medial prefrontal and cingulate cortices; they also reported a correlation between neuropsychological impairment and low rCBF in this area. It is unknown whether the brain regions functionally involved in decision processing could be superimposed with PET findings in depressed patients. In the present study, the recovered patients show an improvement in decision making and attention orientation, which is consistent with these findings.

Conclusion

Unlike the combination of two concurrent tasks, the choice task resulted in an impairment with depressed patients. This pattern of results exhibiting differential sensitivity between two effortful tasks can not be explained by a reduction of available resources, according to a unitary concept that would define attention as an undifferentiated general system. This suggests that depressed patients are able to mobilize resources to complete effortful tasks as far as a decision is not required. When decision processing is involved, there is a marked decline in performance co-occurring with an impairment in orienting attention.

The lack of impairment from single to dual task suggests that sufficient capacity is available to process adequately although the task was predicted to be more effortful. Thus, depression does not interfere with this type of effortful processing. This could be interpreted as follows: previously preempted resources are available thereby, resource allocation depend on the nature and the effortfulness of the task. This is in accordance with the resource allocation explanation of the narrowing of attention model (Ellis 1991). It remains unclear whether depression interferes with decision making processes because they require higher demand according a continuum from automatic through effortful processes or because they account for a specific deficit in depressive disorders. The relationships between the orientation of attention, the decision processes and depressive disorders need to be clarified. These findings emphasize the interest to explore the components of attentional processing in mood disorders.

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