Information processing in depression and anxiety

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SYNOPSIS The memory scanning performance of both unipolar and bipolar depressives and patients with anxiety states was compared with that of control subjects. Four versions of Sternberg's memory comparison task were used. Unipolar depressives showed impaired memory scanning in 3 of the tasks compared with controls, and in one task compared with patients with anxiety states. They were also slower than the other patients and controls in the non-scanning processing stages. They seemed to adopt a less efficient search strategy, and showed more controlled processing as opposed to automatic detection in a paper-and-pencil version of the task.

INTRODUCTION

There is ample evidence that cognitive dysfunction frequently accompanies the mood disturbances in affective disorders such as depression (Beck, 1974; Miller, 1975; Cohen et al. 1982; Glass et al. 1981; Sternberg & Jarvik, 1976; Robertson & Taylor, 1985). Most authors agree that memory is involved, but opinions differ widely as to which aspects are affected. This disagreement may be due to differences in the patient populations studied (e.g. age, aetiology and severity of the illness) and also to variation in the methods used (Glass et al. 1981; Miller, 1975).

Similar problems exist with respect to the differentiation between different types of depression (e.g. unipolar v. bipolar) and between depression and anxiety disorders (e.g. generalized anxiety and panic disorder). Clinical differences exist between anxiety and depression (Roth, 1977; Coryell et al. 1983), but only a limited number of studies has attempted to discern these psychiatric states with psychological tests (Miller, 1975). Traditional psychological techniques such as 'organicity tests' and intelligence scales, e.g. those based on the Wechsler tradition, have not been of much value (Heaton & Crowley, 1981).

Neuropsychological research, on the other hand, has shown that the cognitive deficits in unipolar and in bipolar depression can be differentiated by the use of newer test methods based on a theoretical, well-defined model of brain-behaviour relationships (Flor-Henry & Yeudal, 1979). Cognitive dysfunction has thus been found in anxiety disorders (Insel et al. 1983), as well as in several types of depression (Robertson & Taylor, 1985). The significance of these findings is currently the subject of further study.

There are some indications that the use of newer methods based upon human information processing paradigms might add to our knowledge on cognitive dysfunction in different psychopathological states. This article is directed at the question of whether a particular information processing task can be used to differentiate between unipolar and bipolar depression and anxiety disorders.

Human information processing paradigms generally study psychological functions by analysis of the underlying cognitive processes. The additive factor method (Sternberg, 1969, 1975) is of major importance here and is particularly useful for examining aspects of short-term memory. According to Sternberg, several stages of information processing can be assessed independently by analysing the relation between task factors in their effect on reaction time (RT). It has thus been shown that a linear relation exists between the time that is needed to compare a series of items with similar items in memory, and the number of items held in memory (the memory load). In a graphical
representation of this relation, the intercept is taken to be a measure of the rate of perception and motor response. The slope of this RT set size function is a measure of the memory scanning process. Sternberg proposed the following underlying processing stages: (a) an initial encoding stage; (b) a memory comparison stage (scanning and retrieval); (c) a binary decision stage; and (d) a stage of motor organization and response execution.

Although the assumptions underlying the additive factor method are questioned by some workers (see Sanders, 1983), the method is generally accepted as a valid tool for the differentiation between stages which involve memory (the scanning stage) and the other (non-scanning) stages.

Inferences on the type of processing can be made by varying the stimulus material. For instance, a condition where digits have to be detected among letters gives rise to automatic processing and RTs which are independent of memory load (Shiffrin & Schneider, 1977; Brand & Jolles, 1984). The values of the slope reach zero in this 'consistent mapping' condition. 'Varied mapping' conditions (searching for letters among letters), on the other hand, call for controlled processing. This leads to RTs that are highly correlated with set size (Shiffrin & Schneider, 1977; Fisk & Schneider, 1983).

The paradigm has been regarded as an attractive candidate for application in clinical research because of its firm theoretical basis. This may be why a growing literature exists on the application of the paradigm in the clinic. It is of interest that the slope of the RT-function (memory scanning stage) has been found to be increased in the elderly (Madden & Nebes, 1980) and in the mentally retarded. This may indicate less efficient memory scanning which was also seen in elderly Parkinson patients (Wilson et al., 1980), and sometimes in schizophrenic patients, especially when task demands were complex (compare Sternberg, 1975; Koh et al., 1977; Koh & Wolpert, 1983; Pharr & Connor, 1980). A slower scanning rate was also found in patients with a frontal lobe dysfunction, characterized by planning and concentration disorders, as shown by a paper-and-pencil version of the task (Hijman et al., 1983; Jolles et al., 1982). There have been other inter-group comparisons which have shown differences only in the intercept, reflecting the encoding and output stages.

In depression there has been no evidence so far that the internal scanning speed might be affected. Glass et al. (1981) found that depressed patients were inferior to controls on a memory comparison task, but primarily with respect to the intercept. Hilbert et al. (1976) also found that memory scanning in depressives was not impaired. Likewise, Koh & Wolpert (1983) found no impaired scanning in unipolar and bipolar depressives compared with schizophrenics and no differences in speed with regard to the non-scanning stages of information processing.

This paper is concerned with the question of whether differential cognitive deficits in two types of depressed patients and in anxiety patients can be assessed by the use of the additive factor method and whether a differentiation is possible with respect to processing stages (non-scanning stages versus memory scanning stage) and with respect to the difference

| Table 1. Social and psychiatric characteristics of patient groups and controls |
|---|---|---|---|---|---|
| | Unipolar depression | Bipolar depression | Anxiety disorder | Control group 1 | Control group 2 |
| N | 22 | 15 | 19 | 20 | 11 |
| Sex | M, 18F | M, 7F | M, 9F | M, 10F | M, 8F |
| Mean age (s.d.) | 36 (6.9) | 37 (7.3) | 34 (10.1) | 24 (2.6) | 19-30 |
| Age range | 22-55 | 29-58 | 22-35 | 19-30 | 19-64 |
| Educational level (median) | 5 | 4 | 4.5 | 7.0 | 3.75 |
| DSM-III class* | 200-40(14) | 290-7(15) | 300-21(7) | --- | --- |
| | 296-2(3) | 296-3(2) | 300-30(4) | --- | --- |
| | 296-3(2) | 300-30(4) | 300-0(4) | --- | --- |
| | 300-0(4) | --- | 300-0(4) | --- | --- |

* The number of subjects with a particular DSM-III classification is given in parentheses.
between automatic and controlled processing. A comparison is therefore made between two versions of the memory comparison task. The first version is based upon the task suggested by Sternberg, in which a series of items is presented sequentially on a screen. It was expected that manipulation of the number of response types ('yes' v. 'yes-no') might enable additional inferences to be made on the existence of a motor preparation or organization stage, which may precede the response-execution stage (Brand & Jolles, 1984). The second version was a paper-and-pencil task, in which all test items per set size were presented on a test form in a 12 × 12 matrix. This test version may show inefficient, controlled processing in patients in a simple task where, theoretically automatic detection would suffice (Hijman et al. 1983; Jolles & Gaillard, 1984).

**METHOD**

**Subjects**

Three patient groups and two control groups were used. The patient groups consisted of unipolar depressive patients, bipolar depressive patients and patients with an anxiety disorder. One control group consisted of students and staff members from the clinic; the other consisted of non-academic volunteers.

Table 1 summarizes the social and psychiatric characteristics of the patient groups and controls. Eighteen subjects from the unipolar depressive group were hospitalized at the psychiatric university clinic. One of the patients was left-handed. The tasks, described in the next section, were always administered within the first week of hospitalization. None of the patients received medication while the tasks were administered.

The bipolar depressive patients were all out-patients who were routinely investigated for the possible adverse effects of lithium therapy (Reus et al. 1979; Judd, 1979). All had a history of manic-depressive symptomatology and were treated with lithium citrate of lithium carbonate. Lithium levels were within normal limits. Seven patients were left-handed and 13 patients had multiple cognitive deficits, as assessed by extensive neuropsychological investigation (described in Jolles, 1985; Jolles & van Gent, 1986).

The patients from the anxiety group were out-patients who came to the clinic for neuropsychological investigation and for biomedical screening. Two of the patients were left-handed and none was receiving medication at the time of testing.

There were no statistical differences at the $P = 0.05$ level between any of the patient groups with regard to age. Educational level was classified on a 7-point scale (Verhage, 1964); there was a statistically significant difference between the unipolar group and the anxiety group, in that unipolar patients had a higher educational level ($\chi^2 = 6.6, P < 0.02$).

The control group of students and staff members (control group I) had a significantly lower age and a significantly higher educational level than that of the patient groups. The control group of normal volunteers (control group II) did not differ significantly from the patient groups in respect of age and education.

**Tasks**

There were four tasks (see Table 2). The test items were presented sequentially in tasks 1 and 2 (memory comparison task). Tasks 3 and 4 consisted of a paper-and-pencil version of the memory comparison task. A full account of these tasks is given elsewhere (Jolles & Gaillard, 1984; Brand & Jolles, 1984).

Consonant letters (capitals) were used as
stimuli. In the two memory comparison tasks letters were presented for 1 s on a TV monitor which was about 60 cm in front of the subject. The stimuli were 0.6 cm in height and were presented in white on the centre of a dark-grey screen. The responses were given by thumb-key; stimulus-intervals were kept at 1 s and reaction time (RT) was recorded with an accuracy of 1 ms. The two conditions differed from each other with respect to the number of active responses. In the first task the subject was asked to make positive responses when targets were presented but to do nothing in the case of a non-target. This condition is referred to as single response task or SR task. In the second task both positive and negative responses had to be made for targets and non-targets respectively (dual response task or DR task). These tasks had four parts, corresponding to the set sizes 1–4, and each part consisted of at least 60 trials (48 test trials, preceded by at least 12 practice trials). The memory set items and distractors for each task are given in Table 2. The test trials started following the practice trials as soon as there had been 6 consecutive trials without error. A target was presented on 50% of the trials and the probable occurrence of the targets within each part was the same. Targets and non-targets were presented in the same random order for each subject. No more than 3 targets or non-targets were presented in succession.

Task 3 had three parts (paper-and-pencil version; digits task, D task). In these parts a set of 1, 2 and 4 digits (see Table 2) had to be memorised. The subject was asked to search for these digits on a test form consisting of 144 characters typed in a 12 × 12 matrix, 4 spaces apart from each other. The subject had to mark the targets with a pencil. One-sixth of these characters consisted of items from the memory-set, the rest were capital letters. A practice part with the symbol ‘%’ as the memory set was administered prior to part one (set size 1). The second paper-and-pencil task (referred to as the Letters task or L task) has four parts (memory set sizes 1–4), where items from the memory set and the ‘distractor’ items consisted of letters (Table 2).

Procedure
The tasks were incorporated in a neuropsychological test battery and administered to the patients and to the controls during the course of an extensive neuropsychological investigation. The task order was as follows: D task, L task, SR task and DR task.

During the SR and DR tasks the subject was seated in front of a TV monitor and held the thumb-key paddle assigned to the ‘yes’ responses in the preferred hand. An additional ‘no’ key was held in the non-preferred hand in the DR task. Each part started with presentation of the specific memory set for 5 s via the monitor. The series of practice and test trials was then started and the subject was asked to react ‘accurately but also as fast as possible’.

The procedure was somewhat different during the D and L tasks. The subject and experimenter were seated at a table and were facing each other. Each subtask (1, 2, 4 digits; 1, 2, 3, 4 letters) started with the presentation of the memory set (which was printed on a sheet of paper) for approximately 5 s. The memory set form was then replaced by the test form. The subject was asked to mark all targets on the paper as fast and accurately as possible, going from the top line to the bottom line. A stopwatch was started when the experimenter indicated ‘start’ and stopped when the subject finished the last line.

RESULTS
The linear regression parameters (slope, intercept at set size 1 and correlation coefficient) were calculated for each subject and for each condition and type of response.

1. Memory comparison tasks
Fig. 1 shows the RTs from the single and dual response tasks (SR and DR, respectively) for the patient groups and control group I. The DR task was not administered to the bipolar depressives. The SR and DR tasks were analysed separately. The RTs of the SR task were analysed in a 4 (group) × 4 (set size) ANOVA with repeated measures on the set size factor. There was a significant group effect \( F(3,73) = 4.3, P = 0.007 \) and a significant set size effect \( F(3,219) = 89.4, P < 0.0001 \). Planned comparison analysis revealed that the unipolar and bipolar depressive groups were slower than the control group \( (P = 0.004 \) and \( P = 0.018 \) respectively), and the unipolar depressives were also
slower than the anxiety patients ($P = 0.012$). The contrast between bipolar depressives and the anxiety group was not significant. These differences reflect differences in intercept rather than in the slope, as there was no group × set size interaction. The highest contrast with respect to slope was between the bipolar group and the controls ($P = 0.055$).

The RTs on the DR task were analysed in a 3 (group) × 2 (response type) × 4 (set size) ANOVA with repeated measures on the last two factors. Three of the patients from the unipolar depressive group and two from the anxiety group were unable to complete the DR task. Accordingly, the statistical analysis involved 20 unipolar patients, 17 anxiety patients and 20 controls (control group 1).

There was a statistically significant group effect ($F(2,54) = 7.5, P = 0.002$). Unipolar depressives were slower overall than the anxiety patients ($P = 0.03$) and slower than the controls ($P = 0.0005$). Also, positive responses were made faster than negative responses ($F(1,54) = 82.4, P < 0.0001$) and RT increased with increasing memory set ($F(3,162) = 82.4, P < 0.0001$).

The group × response type interaction was significant ($F(2,54) = 5.86, P = 0.005$). This indicates that the dissociation between positive and negative responses is more pronounced for the unipolar group than for the other groups. The interesting group × set size interaction, which is indicative for slopes differences, was also significant ($F(6,162) = 2.27, P = 0.039$), as well as the response type × set size interaction ($F(3,162) = 7.17, P = 0.0003$).

As these two interactions and the response type factor were significant, a separate analysis was performed on the positive (yes) and negative (no) responses with group and set size as factors. These factors were significant for both 'yes' and 'no' responses. The group × set size interaction was significant only for the 'no' responses ($P = 0.04$). There was a higher slope for the
Table 3. Mean number of false negatives (FN) and false positives (FP) in single and dual response tasks

<table>
<thead>
<tr>
<th></th>
<th>Single</th>
<th></th>
<th>Dual</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FN</td>
<td>FP</td>
<td>FN</td>
<td>FP</td>
</tr>
<tr>
<td>Unipolar depressives</td>
<td>1.04</td>
<td>1.90</td>
<td>2.65</td>
<td>2.70</td>
</tr>
<tr>
<td>Bipolar depressives</td>
<td>2.83</td>
<td>1.93</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Anxiety patients</td>
<td>3.26</td>
<td>2.09</td>
<td>4.06</td>
<td>2.47</td>
</tr>
<tr>
<td>Control group</td>
<td>0.10</td>
<td>0.85</td>
<td>1.60</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Depressives than for the controls (P = 0.023) and the anxiety patients (P = 0.021). A test of the 'yes'-'no' contrasts for each group separately showed differences for the depressive group only (F(3,162) = 5.06, P = 0.003).

With respect to the number of errors the following picture emerges (Table 3). A group x error type (4 x 2) ANOVA on the errors in the SR task showed that anxiety patients and bipolar patients made more errors than the controls (P = 0.02 and P = 0.025 respectively). There were no main effects, and there was no interaction in the error analysis of the DR task.

The positive RTs of SR and DR tasks from patients who completed both tasks were analysed together, in order to determine whether any or both patient groups show greater impairment when task complexity increases. A significant interaction including group and task was not found in a 3 (group) x 2 (task) x 4 (set size) ANOVA, but the task main effect was significant (F(1,54) = 55.8, P < 0.0001). Similar analyses of errors and practice trials yielded no statistically significant results.

2. Paper-and-pencil tasks

The RTs and error data with respect to the paper-and-pencil tasks, digits, and letters, are shown in Fig. 2. The analysis was performed on the data from 23 unipolar depressive patients, 19 anxiety patients, 15 bipolar depressives, and 11 non-academic controls (control group II). The letters task showed a high linear fit (between 0.92 and 0.97). For the digits task the fit was 0.63 for the controls and 0.85 for the unipolar group, with intermediate values for the other two groups.

The linear regression parameters (slope and intercept) were analysed in a 4 (group) x 2 (task) ANOVA. In the analysis of the slope values the group effect just failed to reach significance (F(3,64) = 2.6, P = 0.056), whereas the effect from task was highly significant (F(1,64) = 160.4, P < 0.0001). The unipolar depressive patients had a significantly higher slope than that of the controls in the digits task (4.48 s v. 1.98 s). A similar finding was obtained for the letters task. Moreover, there was a tendency for the slope of the unipolar group to be higher than that of the bipolar patients in this task (P = 0.07). The slope values (in seconds) in the letters task were 14.0 for the unipolar group, 12.6 for the anxiety group, 10.9 for the bipolar group and 9.5 for the controls. No other group contrast was significant and there was no group x task interaction.

The analysis on the intercept values showed a similar, but more pronounced, pattern. There was a significant group effect (F(3,64) = 3.32, P = 0.024), a significant effect from task (F(1,64) = 11.1, P = 0.0002) and no interaction. The unipolar depressives had a significantly higher intercept than the other groups in the digits task. These patients were also significantly slower than the controls and the anxiety patients in the letters task.

Analysis of the errors with group, task and set size as factors showed no group effect nor any significant interaction including group. However, there were more errors in the letters task (F(1,61) = 79.8, P < 0.0001), and more errors with increasing set size (F(2,122) = 42.9, P < 0.0001). The only significant interaction was task x set size (F(2,122) = 26.5, P < 0.0001). This is possibly due to a more pronounced set size effect in the letters task.

Analysis of the RT and errors of the practice trial showed that the unipolar depressive patients were slower than the bipolar patients (F(1,64) = 4.98, P = 0.04), but not slower than
the controls. The bipolar patients made the highest number of errors in the practice trial, but this was not statistically significant.

**DISCUSSION**

This study provides evidence for the presence of cognitive dysfunction in unipolar depression. It was shown that unipolar depressives are generally slower than normal controls and anxiety patients in all tasks, and slower than the bipolar patients in one task. This was indicated by higher intercepts, reflecting the non-scanning stages of information processing (encoding, binary decision, response output stages).

The finding that depressive patients are characterized by slowing associated with non-scanning stages has also been reported by others (Glass et al. 1981; Hilbert et al. 1976; Koh & Wolpert, 1983). However, the present findings also show that, in addition, unipolar depressives showed slower scanning than controls and other patient groups. This was indicated by higher slopes in both paper-and-pencil tasks and in the negative trials of the DR task. This is the more interesting result, in that impaired scanning in depressives compared with controls has not been found in other previous studies, and has not been found frequently in other pathological groups.

A possible explanation for the present positive results, as opposed to previous negative findings, may be the use of newly developed versions of the memory comparison task. The tasks presented here were designed to be more acceptable than conventional tasks in order to enhance the potential applicability in the clinic. Accordingly, the tasks are much shorter than most memory scanning tasks reported previously (e.g. Sternberg, 1975). There are only 48 trials per set size in the SR and DR tasks. The administration of one computer-aided test takes only 10 minutes. The paper-and-pencil versions appeared to be even better as they were less demanding for the patient, whereas the reliability as expressed by the individual linearly coefficients was higher.

The tasks used by Hilbert et al. (1976) and Glass et al. (1981) were also reasonably shorter than the tasks employed in most other studies. Their procedure differs from the present
approach in that a different set of stimuli had to be memorized at each trial (varied set procedure). The present study was characterized by a procedure in which one memory set was presented at the beginning of a series of trials (fixed set). Although the results obtained with both procedures was similar in healthy subjects (Sternberg, 1975), it is fairly certain that the varied set procedure is more demanding and complex for use with patients, because of the changing memory set.

Memory scanning in unipolar depressives was not only slower than that of controls but it was also slower compared with the anxiety patients in the DR task, and there was a tendency towards slower scanning compared with the bipolar patients in the paper-and-pencil letters task. It is interesting that bipolar depressives, who are suspect from memory disorders, were not slower than controls in the scanning and in the non-scanning stages, as these subjects did have cognitive deficits; an extensive neuropsychological investigation identified cognitive deficits in 13 out of 18 bipolar patients. Incidentally, the performance on the memory comparison tasks showed that the bipolar patients made (non-significantly) more errors on all tasks, suggesting greater impulsivity. These results support earlier findings in that bipolar subjects may be well in a psychiatric sense but not with respect to cognitive functions (Jolles & van Gent, 1986). This important finding will be investigated in further research.

Different outcomes with respect to positive and negative responses may be interpreted in terms of the strategies used: unipolar patients showed slower scanning than anxiety patients with regard to the negative responses. In addition, differences between positive and negative slopes were significant for the former patients only. It is thus possible that the depressive patients used a 'self-terminating search strategy' (Sternberg, 1975) more than the other groups. Although the issue of self-terminating vs. 'exhaustive' search is not clearly settled (see Snodgrass & Townsend, 1980; Taylor, 1976), self-termination is said to be less efficient (Sternberg, 1975). This is because a series of binary decisions on the nature of the stimulus has to be made until a match occurs. In exhaustive scanning there is only one decision which is thought to take place at the end of the search. Unipolar depressives are thus not only slower in the scanning and non-scanning stages of information processing, but they also seem to adopt a less efficient search strategy.

Educational background has been associated with processing speed (Hilbert et al. 1976). The present results cannot be attributed to differences in educational level, since the subjects with the lowest level (anxiety patients) did not differ in performance in the SR and DR tasks from the subjects with the highest education (control group I). The same is true for age. However, matched controls were used in the comparison of the paper-and-pencil versions to circumvent possible interpretational problems.

Another objection relates to a different male/female composition in the groups. However, a post hoc analysis, carried out on the data of the SR task including only the females from the unipolar group and the anxiety group, again showed that the depressives were slower. The results cannot therefore be explained by sex differences.

With respect to a comparison between single and dual response tasks, no interaction of group and task was found. Accordingly, no group had significant problems in the inferred motor preparation stage (see Brand & Jolles, 1984). As expected, the DR task which involves two types of response ('yes' or 'no') had a higher intercept compared with the single response condition ('yes'). This was true for all groups to about the same degree. This lack of group differences may be due to high individual differences. It must be noted, however, that a few depressive patients were not able to meet the standard requirements of the DR task, possibly due to a lack of effort or motivation.

The results of the written tasks suggest that patient groups can be differentiated with respect to the ability of automatic detection as opposed to more controlled processing. The unipolar patients had a higher slope and a (non-significantly) higher linearity coefficient than matched controls in the digit task. The slope difference (4.5 vs. 1.98 s) indicates that these patients needed more attention and effort to complete the task. This task requires detection of digits among letters; there is normally no large effect from set size. There may thus be no memory scanning stage in this condition, and this is reflected by a slope near to zero. A direct,
‘automatic’ target identification in long-term memory is sufficient (Madden & Nebes, 1980), and this is what occurs in normal volunteers. It may be compared with the consistent mapping conditions described by Shiffrin & Schneider (1977) where, after considerable practice, zero slope values may be reached. In the pencil-and-paper digits task, however, no practice is needed to reach such a result. These results are presently under investigation.

The high linearity coefficients of the unipolar patients is another indication of more effortful, controlled search in this ‘automatic’ detection task. However, it is too early to decide that depressives have a disability in automatic processing. Automatic processing develops with considerable practice in conditions of consistent mapping (Madden & Nebes, 1980; Logan 1978). Therefore, one cannot exclude the possibility that these patients need more practice to achieve this type of processing.

The authors are grateful to Dr R. Kahn, Dr C. C. Gispen, W. J. Wierd, Dr W. Verhoeven, Dr T. J. Oei and Dr E. van Gent, who took care of patient selection and referral to the Neuropsychology Department. The research was supported by Grant no. 560-264-010 from the Netherlands Organization for the Advancement of Pure Scientific Research.

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