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Depression, Recognition-Memory and Hedonic Tone
A Signal Detection Analysis

G. C. DUNBAR and W. A. LISHMAN

Summary: A signal detection analysis was used in a recognition memory task involving material of varying hedonic tone. Major differences were found between the control and depressed states. Although overall recognition rates were the same, pleasant material was recognised less and unpleasant material more easily by depressives. Neutral material was recognised equally well by both groups. In the depressed state, response biases were altered such that unpleasant material was handled in a preferential way to neutral or pleasant material.

There are many reports in the literature suggesting that depressive illness is associated with impairment of memory and learning (Cronholm and Ottosson, 1961; Kendrick *et al*, 1965; Stromgren, 1977). In a detailed review Miller (1975) considered a number of these studies. Although he found that most of the work supported this conclusion, he suggested that some of the memory deficits reported might be artifactual. Irving *et al* (1970) and Whitehead (1974) used a variety of learning tests in elderly depressives, and found selective rather than global memory impairment. Miller and Lewis (1977) looked at recognition memory in elderly patients with depression and found no difference in "pure memory" between depressives and controls, but did find a difference in "decision-making factors". Cohen *et al* (1982) compared control subjects with a number of depressed patients showing varying degrees of depression. They found that cognitive impairment was a function of both the difficulty of the task and the severity of the depression. Thus there is some controversy as to the apparent learning deficit associated with depression.

The influence of the hedonic tone of material at the time of memory acquisition or memory retrieval has been researched extensively and appears to be important.

Meltzer (1930) in a comprehensive review of the early literature found that in 80 per cent of studies with non-depressed subjects, pleasant material was retrieved from memory more easily than unpleasant material. Although he criticised the methodologies of most of these studies this finding was rather constant. No matter whether ease of retrieval was measured by speed of retrieval or by recall ratios, pleasant memories always seemed to be more readily available than unpleasant memories.

The above work has been replicated and extended using a better methodology (Lishman 1972; 1974) and the finding confirmed. Thus it seems that in non-depressed subjects pleasant memories are more readily available than unpleasant memories.

Some investigators (Menzies, 1935; Waters and Leeper, 1936; Kanungo and Dutta, 1966; Dutta and Kanungo, 1967) have suggested that it is not the type of associated affect that is important, but the intensity.

These two apparently conflicting hypotheses have been considered further by Master *et al* (in press). They showed that both the "intensity of affect hypothesis" and the "type of affect hypothesis" operated simultaneously. Thus pleasant material was recalled more rapidly than unpleasant material and also memories with high associated affect were retrieved more rapidly than memories with low associated affect.

A further consideration is the relationship between the mood state of an individual at the time of memory acquisition, the emotional tone of the material and the mood state at the time of retrieval.

Many workers have suggested that a congruence between mood state and the affective tone of material enhances memory acquisition. In a similar way congruence between mood state and affective tone of material enhances retrieval from memory. The work of Barrett (1938), Mischel *et al* (1976), Isen *et al* (1978), Teasdale and Fogarty (1979) and Bower (1981) indicates the importance of this "encoding specificity" or "mood congruent learning" in healthy volunteers where mood states were artificially manipulated.

These ideas have been extended to depressed patients. Lloyd and Lishman (1975) and Fogarty (1980) found that depressed patients more readily retrieved unpleasant material from memory than

pleasant material. In contrast control groups (non-depressed) retrieved pleasant material from memory more easily than unpleasant material. Their work in depressed patients thus adds support to the notion that congruence between affective state and tone of material interact in retrieval processes.

Signal Detection Theory (SDT)

Signal Detection Theory (SDT) can be applied to the problem. It was originally developed as a general theory of decision making in perception (Swets *et al*, 1961). A particular attraction of the theory has been that it offers a means for solving an old problem in the field of psychophysics and psychophysiology. This problem centres on the need to control or specify an observer's response bias (criterion or set) during a perceptual task. In classical experiments only one parameter of performance is usually obtained and this is taken as a measure of observer sensitivity. No account is made for observer response bias. These two aspects of performance are thus confounded. SDT provides a means of separating observer sensitivity or ability to discriminate (d'), from response bias, criterion or set (ß).

Over the years SDT has been applied to a large number of experimental situations other than perceptual tasks (Swets, 1973; Pastore and Scheirer, 1974). The usefulness of the theory has been confirmed and its application to recognition-memory has been of particular interest.

A recognition memory test typically involves presenting the subject with a list of items consisting of old items (items that were in an inspection list presented previously) and new items. The subject is required to examine each item and to indicate whether or not it was a member of the inspection list.

The usefulness of the signal detection model has been confirmed by many authors (Banks, 1970; Miller, 1975; Cutting, 1981). Not all investigators however, accept the application of SDT to recognition memory (Richardson, 1979). It can be argued that the basic assumption of SDT (normal distributions of equal variance and an optimally located criterion) may not always be met. Likewise, receiver operating characteristics (ROC curves) are rarely calculated to check this (Swets, 1973). However, in a study by Healy and Kubovy (1978) the authors compared the various ways of handling data from recognition memory tests. They found that d', the variable generated by SDT, "remained the preferred index of performance".

In the present study SDT was used to look further at the apparent change of memory processes in depression, and to consider the various decision making strategies used when subjects with differing affective states handle emotionally toned material.

Method

Subjects

Two groups of subjects were tested—depressed patients and healthy controls. The depressed group were all hospitalized and were suffering from a depressive illness which conformed to the criteria of Feighner *et al* (1972). All were receiving tricyclic antidepressant medication at the time of testing. Patients with a score of less than 16 on the Hamilton depression rating scale were not included. Also excluded were patients with a history of schizophrenia, epilepsy, organic brain damage or treatment with electroconvulsive therapy within the last six months. The control group was composed of paramedical staff from the same hospitals. They had never received any medical treatment for depression and were willing to take part in the study.

Procedure

Each subject was tested individually by one of the authors (GCD). They were instructed that they would be shown a series of cards upon which would be a single word. The cards would be shown for one second and they were told to concentrate on the word shown. They were told to shift their attention to the next word as soon as it appeared. They were not asked to remember the words, nor were they told that later they would have to make decisions about the words. Subjects then had a "dummy run", during which they were shown 12 cards. During this run a check was made to ensure that they could see the words clearly and were completely comfortable with the presentation method. They were then shown a further 36 cards during the "inspection" or "learning" part of the experiment. This list consisted of 12 words with high hedonic tone (good words), 12 words with low hedonic tone (bad words) and 12 words with intermediate hedonic tone (neutral words). The words used are shown in the Appendix.

These words were taken from the studies of Broadbent and Gregory (1967). They were presented in random order. Each word appears in the English language with a frequency of 10–50/million (Thorndike and Lorge, 1944) and has been rated by a large population for hedonic tone.

After exposure to the words the subjects were asked to complete a Beck Depression Inventory (Beck *et al*, 1961), the Eysenck Personality Questionnaire (Eysenck and Eysenck, 1975) and the Mill Hill Vocabulary Scale. The depressed group were also scored on the Hamilton Depression Rating Scale (Hamilton, 1960). After completion of the questionnaires, which took approximately 30 minutes, the "recognition" part of the experiment was undertaken. Subjects were again exposed to cards on which were printed words of varying hedonic tone. During this

second occasion 72 words were presented which consisted of the 36 words seen during the learning part of the study (old words) plus 36 new words. The 36 new words had a similar frequency in the English language to the old words, and included 12 good words, 12 neutral words and 12 bad words. The 72 words were presented in a new random order. During the recognition part of the study no time limitation was involved. Subjects could see the word for as long as they wished. However, a definite decision had to be made as to whether or not they recognised each word. A positive response indicated that subjects recognised the word as being from the learning trial, while a negative response indicated they did not. No matter how unsure the subjects felt about the word recognition a definite response was required but no attempt was made to rate the confidence of this decision. In a pilot study ratings had been attempted in order that ROC-curves might be plotted for the analysis. However, such ratings had proved too demanding for patients with a clinically significant depression. After making decisions on each word separately, the 72 words were shown a second time and subjects were asked to classify each word as being "good", "neutral" or "bad".

Results

General characteristics

The groups sampled were well matched for age, sex and IQ (Table I), there being no significant differences between groups on these variables. Personality profiles as measured by the EPQ showed significant differences between groups with regard to N–Scores ($P < 0.001$), E–Scores ($P < 0.015$) and P–Scores ($P < 0.017$). Although significantly different from the control group, the depressive scores were no different from those given by Eysenck for endogenous depression (Eysenck and Eysenck, 1975). The control group likewise did not differ from Eysenck's controls. The

Table I
General characteristics of subjects

		Control group	Depressed group
Sex	– Male	9	9
	– Female	21	21
Age	– years	40.3 ± 14.7	41.7 ± 12.8
IQ	– verbal	104.6 ± 9.8	99.0 ± 12.8
EPQ	– N-score	9.5 ± 4.4	17.4 ± 3.5
	– E-score	11.4 ± 4.7	7.9 ± 6.0
	– P-score	2.9 ± 2.6	4.6 ± 2.9
	– L-score	9.0 ± 4.6	9.9 ± 5.3
Beck score		5.6 ± 3.7	28.3 ± 11.4
Hamilton score		–	21.5 ± 5.34

Table II
Agreement with Broadbent's ratings

	Hedonic tone (according to Broadbent)	Agreement	
		Number	%
Control subjects	good	492	68
	neutral	510	71
	bad	586	71
Depressed patients	good	513	74
	neutral	403	58
	bad	614	88

Table III
Mean hit rates

Word	Controls	Depressives
Good	8.8 ± 2.2	6.5 ± 2.3
Neutral	7.0 ± 2.6	6.1 ± 2.6
Bad	7.8 ± 1.9	8.7 ± 2.0

Table IV
Mean false alarm values

Word type	Controls	Depressives
Good	3.3 ± 1.5	3.1 ± 1.9
Neutral	3.1 ± 1.6	2.5 ± 1.4
Bad	4.3 ± 2.4	4.3 ± 2.8

Table V
Mean d'

Word type	Controls	Depressives
Good	1.3 ± 0.6	0.9 ± 0.6
Neutral	0.9 ± 0.6	0.9 ± 0.6
Bad	0.8 ± 0.5	1.1 ± 0.6

Table VI
Mean β

Word type	Controls	Depressives
Good	1.0 ± 0.5	1.4 ± 0.8
Neutral	1.2 ± 0.5	1.5 ± 0.6
Bad	1.1 ± 0.5	1.1 ± 0.6

depressive group scored significantly higher than the control group on the Beck Depression Inventory ($P < 0.001$).

Hedonic tone of words

The number of words classified in the same way as Broadbent's original ratings are listed in Table II. There were similar rates of agreement in both the control and depressed groups. However, the control group tended to be rather more consistent, with agreement rates of approximately 70 per cent for all three types of word. The depressed group showed more agreement for good and bad words than for neutral words. Agreement rates were sufficiently high for the groups to be considered similar to each other in their "attribution" of hedonic tone to the various words.

Recognition analysis

During the recognition part of the experiment there could be one of four results:—

(a) old word, correctly recognised (Hit);
(b) new word, incorrectly recognised (False alarm);
(c) old word, incorrectly not recognised (Miss); and
(d) new word, correctly not recognised (Correct rejection).

The Hit rate (HR) and False alarm rate (FAR) were calculated for each subject and each word type (good, neutral, bad) according to the Broadbent classification. The mean results are presented in Tables III and IV. Because HR and FAR, or the derived variable Hit rate minus False alarm rate (HR-FAR), are not bias-free measures of recognition performance (Swets *et al*, 1961) further data manipulation was undertaken. Using the HR and FAR it was possible to calculate d' and ß (Swets *et al*, 1961). Tables (Hochhaus, 1972) were used to derive d' and ß for each subject and each word type. The mean results are presented in Tables V and VI.

ANOVA for d' values showed no main group effect nor main word-type effect, but a highly significant group × word-type interaction ($df = 2/116$, $F = 10.16$, $P < 0.0001$). Consideration of individual between-group differences for word type showed that controls had significantly higher d' values for good words than did depressives ($P < 0.0003$), while depressed patients had a significantly higher d' value for bad words than did controls ($P < 0.038$). Consideration of the within-group, word-type differences showed that in the control group good words had a significantly higher d' value than neutral ($P < 0.04$) or bad ($P < 0.001$) words, while in the depressed group bad words had a significantly higher d' value than good words ($P < 0.05$).

These results indicate that overall there was no difference in recognition rates between controls and depressives. However, the two groups did recognise different types of material with differing ease. Thus, controls recognised pleasant material more readily than depressives and good material more easily than either neutral or bad material. Depressed patients however, recognised unpleasant material more readily than controls and bad material more easily than good material.

ANOVA for ß values showed no main group effect but a significant main word-type effect ($df = 2/116$, $F = 4.21$, $P < 0.017$) and a significant group × word-type interaction ($df = 2/116$, $F = 4.48$, $P < 0.013$). Consideration of the individual between-group differences for word-type showed that depressed patients had significantly greater ß values for good ($P < 0.013$) and neutral ($P < 0.048$) words than did controls. Individual within-group word-type differences showed that in the depressed patients good ($P < 0.02$) and neutral ($P < 0.01$) words had a significantly higher ß values than bad words. A high ß value here indicates a conservative criterion for accepting recognition of old words. The results show that the response bias differed between controls and depressives depending on word-type. Thus depressed patients showed a greater bias against recognising good and neutral words than did controls. Likewise depressives showed a greater bias against recognising good and neutral material than bad material. This within-group difference was not seen in the controls who showed no difference in response bias across word-type.

Discussion

The use of SDT analysis in recognition memory generates the statistic d', a bias-free measure of performance, which can be considered to represent "pure memory" or "strength of memory trace". The results indicate that the strength of a memory trace varies according to the hedonic tone of material and according to the affective state of the individual at the time of establishing the memory trace. Considering the d' values for neutral words only, no between-group differences could be found. This indicates that "pure memory" was not impaired by depression, when the recognition task involved material devoid of hedonic tone. This finding is in agreement with those of Miller and Lewis (1977).

This is an important finding since it indicates that "pure memory" processes in depression were not impaired and that some other factor was operating to produce the apparent changes seen. Consideration of the other d' results throws some light on the matter.

In the non-depressed state pleasant material (good words) established a significantly stronger memory

trace than neutral or unpleasant material (bad words). On the other hand, in the depressive state, this preferential retention of pleasant material was lost. Instead, unpleasant material established a significantly stronger memory trace than pleasant material. This result is in accordance with the notion of mood congruent learning Bower (1981) or encoding specificity (Tulving and Thomson, 1973). It provides evidence that a congruence between affective state and hedonic tone of material leads to establishment of a stronger memory trace, when compared to situations where this congruence is lacking.

The finding for positive material is also in agreement with the general results in the literature (Meltzer, 1930; Lishman, 1974; Mischel *et al*, 1976; Isen *et al*, 1978; Teasdale and Fogarty, 1979). Although different experimental designs were used in these studies, all found memory for pleasant material to be enhanced over that for unpleasant material in a positive (non-depressive) mood state. In a negative (depressive) mood state this preference was lost. A more detailed comparison with the results of Mischel *et al* (1976) indicates that these authors found changes in d' very similar to those reported here. Their methods approximate closely to the present study, and their results for d', if expectancy is controlled, exactly parallel the present findings.

Interpretations of why congruence between mood state and material leads to enhanced memory are speculative. One possible mechanism might be the intensity (or impact) value of the hedonic tone of the material at the time of memory acquisition. In the control (non-depressed) state, pleasant material might be perceived as having increased associated affect when compared to the depressed state. Conversely, in the depressive state unpleasant material might be perceived as having increased associated affect when compared to the control state. This differential in perceived associated affect dependent on mood state would lead to increased salience for different material and thus to the laying down of memory traces with varying strengths.

Another possible mechanism is that of selective attention (i.e. material congruent with mood may be attended to selectively). This would lead to a stronger memory trace for congruent material, than for material where congruity was lacking.

An alternative explanation concerns the decay of memory traces. Holmes (1970) showed that in non-depressed (control) states, unpleasant memories decay faster than pleasant memories. Hence the apparent increased ease of retrieval for pleasant memories. In the depressed state this differential decay rate may be lost or reversed. Thus changes in the relative decay rates for pleasant and unpleasant material might explain the different d' values seen between controls and depressives. Whatever the mechanism, the finding that d' varies in such a way that increased d' values were found in association with a congruence between mood state and the hedonic tone of material, lends support to the concept of mood congruent learning in both controls and depressives.

Considering the findings for ß, significant differences in response bias were seen. ß remained constant for all three word types in the control group, but in the depressives the good and neutral words had significantly higher ß-values. Thus controls showed no variation in response bias between word-type while depressives had a response bias against the recognition of good and neutral words.

This finding is at variance with the original hypothesis. Initially it was thought that in the depressed state response bias or criterion would be relaxed for unpleasant material when compared to controls. This was not found. Instead depressives seemed to increase their bias against good and neutral words while the bias for bad words remained no different to that of controls. The net result however, was the same, in that they showed a preferred recognition for unpleasant material.

In agreement with these findings Miller and Lewis (1977) found similar evidence of high criterion levels in depression. In that study, however, non-verbal material was used. The present results suggest that depressives tend to set high criterion levels, but this is not a global effect and varies with, amongst other things, the emotional tone of the material being handled.

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Appendix

Words shown on the first (inspection or learning) exposure, in order of presentation

Hedonic Tone
(according to Broadbent)
G = good, N = neutral, B = bad

1.	Cheese	G	19.	Sixth	N
2.	Bleed	B	20.	Brute	B
3.	Bride	G	21.	Plough	N
4.	Starve	B	22.	Peach	G
5.	Crow	N	23.	Hymn	G
6.	Chest	N	24.	Mode	N
7.	Dread	B	25.	Mock	B
8.	Mirth	G	26.	Cash	G
9.	Brass	N	27.	Halt	N
10.	Scream	B	28.	Moist	N
11.	Flake	N	29.	Barn	N
12.	Cruise	G	30.	Plum	G
13.	Flock	N	31.	Pinch	B
14.	Ripe	G	32.	Soup	G
15.	Crash	B	33.	Lawn	G
16.	Tune	G	34.	Snake	B
17.	Cruel	B	35.	Glove	N
18.	Groan	B	36.	Mob	B

G. C. Dunbar, B.Sc., M.R.C.Psych., *Medical Adviser, C.N.S. Drugs, Medical Research & Development Unit, Organon International B.V., Oss, Holland*

W. A. Lishman, M.D., F.R.C.P., F.R.C.Psych., *Professor of Neuropsychiatry, Institute of Psychiatry, De Crespigny Park, London SE5*

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