Brit. J. Psychiat. (1980), **137**, 26–37

ECT: III: Enduring Cognitive Defecits?

By D. WEEKS, C. P. L. FREEMAN and R. E. KENDELL

SUMMARY Cognitive function was compared in carefully matched groups of ECT and non-ECT treated depressives and in matched normal volunteer controls on admission, at 4 months and at 7 months. ECT caused little impairment at 4 months and no impairment at 7 months on a comprehensive cognitive test battery. Severity of depression had a marked effect on cognitive function. Within the ECT group bilateral ECT caused more impairment than unilateral ECT one week after a course but 3 months later the differences had disappeared. They were equally antidepressant.

The purpose of the study was to examine whether ECT has any enduring effects on cognitive function when it is used to treat depressed patients.

ECT is the most effective treatment for seriously depressed patients. It is also a controversial treatment, and much of the concern over its use centres on the effect it has on memory. It is known that ECT produces a brief retrograde amnesia in a rather unpredictable patchy fashion. It also produces a certain degree of anterograde amnesia and difficulty in learning new material. It is widely accepted by psychiatrists that this post-treatment memory impairment is temporary and reversible, but critics dispute this and claim that ECT produces permament impairment.

The published studies to date support the former view but many of them are inadequate on methodological grounds. The early work mixed various types of schizophrenic and depressed patients and it is known that some forms of schizophrenia are associated with intellectual deterioration. The cognitive tests used have rarely been comprehensive and sometimes not sensitive enough to detect small changes in cognitive function. Tests of cerebral dominance have often been inadequate. Some studies have taken little or no account of how depressed the patients were when tested, and it is known that depression can markedly affect test performance.

Wilcox (1954) studying 23 psychotic females who had been given ten bilateral ECT showed that they had returned to their pre-ECT level of memory within two weeks of ECT and that when followed up at twelve weeks they had shown further slight improvement. Korin *et al* (1956) found that ability to learn common words had returned to pre-treatment levels three weeks after a course of ECT. Cronholm and Molander (1964) concluded that one month after a course of ECT there were no ECT-related deficits on tests of non-verbal, verbal or personal remote memory, and that scores on tests requiring immediate reproduction of newly presented material had improved. Kendrick and Post (1967), in a study on elderly depressed patients which compared ECT with imipramine, found that there were no learning deficits in the ECT group either 24 hours or several months after treatment.

Halliday *et al* (1968) compared bilateral ECT with unilateral non-dominant and unilateral dominant ECT. They used a battery of six tests and tested their subjects after four ECT and at three months. After four ECT they found the dominant unilateral group to be most impaired on tests of verbal learning, both immediate and delayed. The non-dominant group were most impaired on tests of non-verbal learning. The bilateral group were mid-way between the two. When they re-examined some of the patients at three months the non-dominant unilateral group were no longer impaired on any of the tests, the dominant unilateral group were still significantly impaired on the two tests of verbal learning, and the bilateral group remained impaired on one test of delayed non-verbal learning. The bilateral group had also developed slight but statistically significant impairment on the digit span test.

Miller (1970) looked specifically at verbal learning after ECT and found no deficits at either five days or nine days post-treatment. Turek and Block (1974), in an exemplary study in which patients were given no concurrent medication, found that scores on the Wechsler memory scale

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

became progressively impaired during a course of treatment, but then rose to pre-treatment levels within one week of the course finishing. Squire and Chase (1975) in a retrospective study using six different tests of delayed retention and memory could find no persisting deficits six to nine months later. Summarizing the above work and including studies by Stone (1946); Hemsi *et al* (1968); Brower and Oppenheim (1951); Jackson (1978) and Heshe *et al* (1978) there is a mean recovery time to pre-ECT cognitive function or better of 72 days, with a range of from 7 to 270 days. The wide range is probably due to different types of cognitive function being tested.

These findings parallel results of animal experimentation. There have been 18 studies into the possible permanence of an ECS-induced cognitive deficit. Fifteen showed that for courses averaging 9 shocks memory function recovered completely in an average of 7 days (range 8 hours to 23 days). (Braun *et al*, 1957; Broadhurst *et al*, 1952; Brown and Simpson, 1956; De Vietti and Bucy, 1975; Horowitz and Stone, 1947; McGinnies and Schlosberg, 1945; Murphree and Peters, 1956; Nielson, 1968; Russell, 1949; Siegel, 1943; Siegel *et al*, 1949; Stern, 1956; Stone, 1946a; Williams, 1959; Zinkin and Miller, 1967). Three unfavourable reports involved between 18 and 25 shocks given once daily. Brown and De La Garza's (1953) results were inconclusive as follow-up was broken off after fifteen days. Brown and Wilbanks (1952) found that spatial learning was impaired post-ECS but again follow-up was not extended. Braun *et al* (1949) found that there was a diminishing learning impairment after 30 days but that impairment of retention was still present at 60 days.

Thus the indications are that ECT does not cause enduring effects on memory. Many studies have used return to pre-ECT level of memory functioning as evidence of lack of impairment. As ECT is given for severe depression and severe depression impairs memory we think that using such a criterion is misleading. Before ECT, patients may have very poor cognitive function because they are depressed. Few studies have used normal or non-depressed controls. It is therefore not possible to conclude from previous work that patients who have had ECT and whose depression has been treated do not have memory impairment.

Methods

Subjects

All patients admitted to the Royal Edinburgh Hospital with an admission diagnosis of depressive illness were screened to see if they fulfilled the following seven inclusion criteria: age between 18 and 70; clinical diagnosis of depressive illness; minimum score of 15 on the Hamilton rating scale; no evidence on clinical examination of organic brain disease, epilepsy, previous neurosurgery, alcoholism, or schizophrenia (in doubtful or borderline cases the Present State Examination (PSE) was used to screen individuals for depressive illness and exclude schizophrenia or atypical psychoses); no history of head injury requiring admission to hospital (in Edinburgh all patients presenting at hospital with a history of loss of consciousness, however short, are admitted overnight); no ECT in the previous six months; not taking major tranquillizers regularly.

Accepted patients were dropped from the study because of the development of a major physical illness during the study (e.g. myocardial infarction or carcinoma); major tranquillizers being prescribed; any self-poisoning that resulted in loss of consciousness; receiving a second course of ECT during the follow-up period. (Most patients received a single course of ECT, but a few received further treatments. If these were separated by less than two weeks from the original course the course was regarded as continuous).

Matching of subjects

Of the patients who fulfilled all the trial criteria 51 subsequently went on to receive a course of ECT, 15 unilateral ECT to the non-dominant hemisphere and 36 bilateral treatment. From those depressed patients who did not receive ECT and who fulfilled all the trial criteria, 51 patients were matched to the ECT group on age, sex, social class, educational attainment, and severity of depression. (See Table I).

From a larger group (n = 130) of community volunteers, 51 subjects were matched to the ECT group on age, sex, social class, educational attainment and verbal intelligence. (See also Table II). None of these subjects suffered from a formal psychiatric illness and none was receiving regular psychotropic medication. The purpose of this normal control group was to ascertain baseline levels on each of the psychometric tests when given by the same tester in the same manner. There were no significant differ-

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

TABLE I

Matched variables of patient groups

	ECT group (n = 51)		Non-ECT group (n = 51)		Non-patient controls (n = 51)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	52.4	12.5	49	14.8	51.0	14.2
Education (years)	10.8	3	10.6	2.5	10.5	2.0
Social class (numbers of people)						
I	6	–	7	–	9	–
II	10	–	5	–	2	–
III	16	–	19	–	26	–
IV	12	–	10	–	9	–
V	7	–	10	–	5	–
Initial level of depression						
(by Hamilton)	26.6	7.5	26.4	7.7	Not applicable	
(by Wakefield)	25	7	24.5	5.6	Not applicable	
Sex distribution						
Females N =	34	–	30		34	
Males N =	17		21		17	

TABLE II

Resemblances between patient groups

	ECT group		Non-ECT group		Non-patient controls	
	Mean	SD	Mean	SD	Mean	SD
Verbal intelligence	99.5	12.8	98.2	9.4	101.9	10.6
Non-verbal intelligence	95.9	14.0	94.4	13.5	96.9	13.3
Number of prior episodes of						
depression	2.6	2.9	2.04	2.4	–	–
mania	0.04	0.28	0.12	0.38	–	–
physical illness	0.73	0.85	0.82	1.09	–	–
Cerebral dominance (laterality) in 51 cases						
Left	44		44		49	
Right	3		4		1	
Mixed	4		3		1	
Middlesex H.Q.						
total symptom score	49	12.4	49	10.8	25.8	5.4
free floating anxiety	11.2	3.2	11.3	2.8	5.8	3.5
phobic fear	7.4	4.2	7.3	3.7	3.8	2.7
obsessionality	9.5	3.7	9.9	2.9	6.7	3.4
somatisation	9.7	3.6	10	3	5.2	2.8
depression	11.2	3.2	10.8	3	4.3	3.3
hysterical personality	3.8	3.2	4.4	2.9	4.6	3.2
Broadbent cognitive F.Q.						
total score	71.8	19.7	69.2	15	69	13.8

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

ences between the three groups in matched variables and the patient groups, whether ECT of non-ECT received the same mean doses of tricyclic antidepressants and lithium. The two patient groups had one important difference, however; on the Newcastle scale (Carney *et al*) the ECT group scored a mean of 6, the non-ECT 4.75 ($P < .01$) and therefore the ECT group was slightly more 'endogenous'.

Shortly after admission each subject was interviewed, by C.P.F., who collected background information and rated the subject's type and severity of depression. Cognitive assessment was conducted (by D.J.W.) within 24 hours of the first interview. Each rater was blind to the other's assessment and at this stage it was usually not known for certain whether the subject would receive ECT or chemotherapy, this being decided independently by the patient's consultant.

The ECT group were tested before ECT, one week after the course was completed and then at three months and six months after the course was completed. The non-ECT group were retested at four months and seven months after initial testing, thus allowing one month for an average course of ECT.

The tests were administered in a random order and there were four completely parallel and equivalent test batteries which were administered in a counterbalanced order. The selection of a particular order was by use of a random numbers table. This was to avoid subtest interaction effects wherever possible.

Details of the 19 tests used to measure a wide range of cognitive functions are given in the Appendix. Ratings of depression were made independently on each testing occasion using the Hamilton scale (Hamilton, 1960), Wakefield self rating scale (Snaith *et al*, 1971) and a number of visual analogue scales.

ECT

ECT was given twice-weekly using an Ectron Mark IV machine. All patients received a bi-directional modified sine wave current with a stimulus duration of 1.5 seconds. The actual amount of current delivered depends on the inter-electrode resistance viz. the resistance of the subject's head. This may vary greatly from subject to subject but for a typical resistance of 470 ohms the Ectron Mark IV delivers 36 joules of current. For bilateral ECT the standard temporal electrode placement was used (4 cms perpendicularly above the mid-point of an imaginary line drawn from the external auditory meatus to the lateral angle of the eye). For unilateral ECT Lancaster's position was used (Lancaster *et al*, 1958). All ECT patients were premedicated with atropine sulphate 0.6 mg, 30 to 40 minutes before ECT and received suxamethonium chloride 20 to 40 mg as muscle relaxant and sodium thiopentone 150 to 300 mg as anaesthetic. Laterality was assessed on a 12 point scale which ranged from simple measures of preferred hand for writing to speed of card dealing with either hand.

Other variables

Careful note was kept of all types and dosages of medication. Dosages were converted into simple five-point scales using amitriptyline equivalents for antidepressant regimes. Subjective side-effects were recorded on each testing occasion using a four-point scale from absent to severe.

Number of subjects tested at each occasion

Of the 51 subjects in the ECT group all 51 were tested post ECT, 45 at four months and 41 at 7 months. In the non-ECT group 47 were tested at 4 months and 46 at seven months. Four subjects, two in each group, committed suicide. Other subjects were excluded because of drug overdoses (2), development of physical illness (3), and non-attendance (6). There were no significant differences between the groups with respect to these variables.

Note on statistics

Dependent t tests were used only on comparisons within groups. For all comparisons between groups independent t tests were used. Because of the large number of tests used results are only reported when the difference in results produced a P value of $P < 0.1$. It can therefore be assumed that all scores on tests not reported did not even approach significance. As measured by

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

the Hamilton and the Wakefield scales both the ECT and non-ECT groups improved significantly. All the ECT group's improvement occurred over the course of their ECT and this improvement was maintained at 4 and 7 months. We did not test the non-ECT group again until 4 months and by that time their depression had improved as much as that of the ECT groups. There was no difference in depression scores between the two groups at 4 months or at 7 months.

Results

ECT group one week after treatment

Much to our surprise the ECT group did not perform worse on any test after treatment than they had beforehand. In fact they improved significantly on visual design learning, on measures of psychomotor speed, on immediate repetition of anomalous sentences, and on the cube analysis test. Their verbal memory was also significantly more accurate in that they committed themselves to fewer semantic false positives. The improvement on visual design learning and verbal memory semantic false positives brought the ECT group into the normal range for these particular tests. On several of the other tests there were changes in the direction of improvement but these did not reach significance. Details are given in Table IV.

Details of the first (pre-treatment) testing are given in Table III. The group went on to receive ECT started the study significantly more impaired on 9 out of the 19 cognitive tests. There was no test where the ECT group began the study with a better score than the non-ECT group.

Thus ECT had not produced any further impairment in cognitive function; on a simple three-point side effects scale there was a small rise from a mean of 1.4 to 1.65 indicating that the patients felt their memory to be slightly but not significantly more impaired after ECT than before.

TABLE III

Initial differences (pre-treatment) between two patient groups

Test	Normal level		ECT group		Non-ECT group		Significance (difference between ECT and non-ECT groups)
	Mean	SD	Mean	SD	Mean	SD	
Famous personalities of 1970s	15	2.8	12.3	4.7	15.2	3.8	P < .001
Delayed recall	5.5	1.6	4.4	1.9	5.5	1.4	P < .001
Delayed recognition	8.5	0.9	7.3	1.9	8.2	1	P < .01
Verbal memory—semantic false positives	0.94	1	1.23	1	0.75	0.7	P < .02
Auditory verbal learning	26	7	38	18.6	31	12.9	P < .05
Decision time (internal information processing speed)	387 msec.	128	599 msec.	337	483 msec.	183	P < .05
Personal remote memories	21.5	2.5	20.1	4.1	21.7	2.6	P < .05
Movement time	295 msec.	114	593 msec.	552	425 msec.	213	P < .05
Fluid movement (card dealing)	13.8 sec.	3.8	20.4 sec.	9.4	16.8 sec.	8.5	P < .05
Visual memory structural false positives	0.33	0.6	0.61	0.85	0.33	0.5	P < .10
Anomalous sentences repetition (errors)	8.7	6	14.7	9.7	11.35	7.8	P < .10
Visual design learning	21.8	11.2	33.2	18	27.5	14.8	P < .10
Famous personalities of 1960s	13.2	3.2	10.4	4.6	11.9	4.7	P < .10

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

TABLE IV

ECT group—comparison of measures before and 1 week after treatment

Variable	Before ECT		After ECT		Significance (2-tailed)	Normal level	
	Mean	SD	Mean	SD		Mean	SD
Visual design learning	33.2	18	26	11.3	P < .005	21.8	11.2
Decision time	599 msec.	337	455 msec.	161	P < .005	387 msec.	128
Movement time	593 msec.	552	404 msec.	205	P < .005	295 msec.	114
Verbal memory semantic false positives	1.24	1	0.71	1	P < .01	0.94	1
Anomalous sentences repetition	14.7	9.7	12.1	8.2	P < .05	8.7	6
Cube analysis (errors)	18.3	16.1	13.8	13	P < .05	16	14.7
Positional learning	25	13.6	20.7	10.9	P < .05	20.8	13.8

On all other cognitive tests the ECT group did not change significantly.

TABLE V

ECT vs non-ECT at four months

	ECT group		Non-ECT group			Normal level	
	Mean	SD	Mean	SD	Significance	Mean	SD
Famous personalities of 1970s	12.9	5.2	15.4	3.7	P < .01	15	2.8
Mental set-shifts, correct alternations	1.53	0.6	1.2	0.7	P < .05*	1.4	0.6
Anomalous sentences repetition (errors)	13.8	8	10.8	6.9	P < .10	8.7	6
Personal remote memories	20.1	3.6	21.35	2.8	P < .10	21.5	2.5

* ECT group significantly less impaired.

On all other cognitive tests there were no significant differences.

Testing at four months

When the ECT and non-ECT groups were compared at this stage (Table V) their scores on nearly all the cognitive tests were very similar. Only two tests distinguished between the groups at a significance level of 5 per cent or less. The ECT group were not able to remember the names of famous personalities from the decade 1970–79 as well as the non-ECT group, but they did significantly better on the test of mental set shifting. This is a test which gives a measure of short-term attention and concentration, and ability to plan ahead what you are going to say. On this they did slightly better than the normal controls, and the non-ECT group slightly worse.

Testing at seven months

Only one test differentiated the two groups at a statistically significant level (see Table VI).

There was, however, a tendency for both groups to obtain slightly impaired scores on a number of tests when compared with the normal controls. In other words, both patient groups were still performing less well than normal people on no psychotropic medication and with, presumably, few symptoms of depression.

Unilateral vs bilateral ECT

It is tempting to conclude that ECT is causing no cognitive impairment at all, even in the short-term, but this is not so, as can be seen

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

TABLE VI

ECT vs non-ECT at seven months

	ECT group		Non-ECT group			Normal level	
Test	Mean	SD	Mean	SD	Significance	Mean	SD
Logical memory	14.3	4.6	12.2	3.4	P < .05 (In favour of ECT group)	13.4	3.6

On all other cognitive tests there were no differences between the two groups and none even approached significance.

TABLE VII

Matching of bilateral ECT group with unilateral non-dominant group

	Unilateral ECT group (N = 15)		Bilateral ECT group (N = 15)	
	Mean	SD	Mean	SD
Age	50.3	14.4	52.3	13.2
Social class	2.9	1.3	3.1	1.3
Educational level	11.7	3.4	11.2	3.4
Verbal intelligence	101.1	12.6	101.7	15.4
Sex distribution	10 females:5 males		10 females:5 males	
Number of ECT	7.4		7.2	

There were also no significant differences on smoking and drinking habits, physical illnesses, ECT complications, number of shocks per patient, Newcastle diagnostic index, laterality, non-verbal intelligence, severity of depression, neurotic symptoms, or drug regimes.

TABLE VIII

Comparison between scores of bilateral and unilateral ECT groups

	Bilateral ECT group		Unilateral ECT group			
	Mean	SD	Mean	SD	Significance	Occasion
Verbal memory—structural false positives (change)	+0.6		−0.7		P < .01	1 week post-ECT
Visual design paired-associate learning	31.5	12	23.5	9.6	P < .05	1 week post-ECT
Delayed recall	3.9	2	5.5	1.7	P < .05	1 week post-ECT
Auditory verbal paired-associate learning	35.7	16.7	28.4	10	P < .01	1 week post-ECT

All differences favour the unilateral non-dominant ECT group. Comparisons on all other tests showed no significant differences.

when patients receiving unilateral and bilateral ECT are compared. From the 36 patients receiving bilateral ECT 15 were blindly matched individually to the 15 patients who had received unilateral ECT (Table VII). It was found that unilateral ECT was equally effective in relieving depressive symptoms at one week, four months and seven months follow-up testings.

However, when the results on cognitive testings were compared, the unilateral ECT group were significantly less impaired at the one week post-ECT testing (Table VIII). In fact the unilateral ECT group were scoring close to the normal control levels on many tests within one week of treatment. By four months the bilateral group had caught up and were no longer more

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

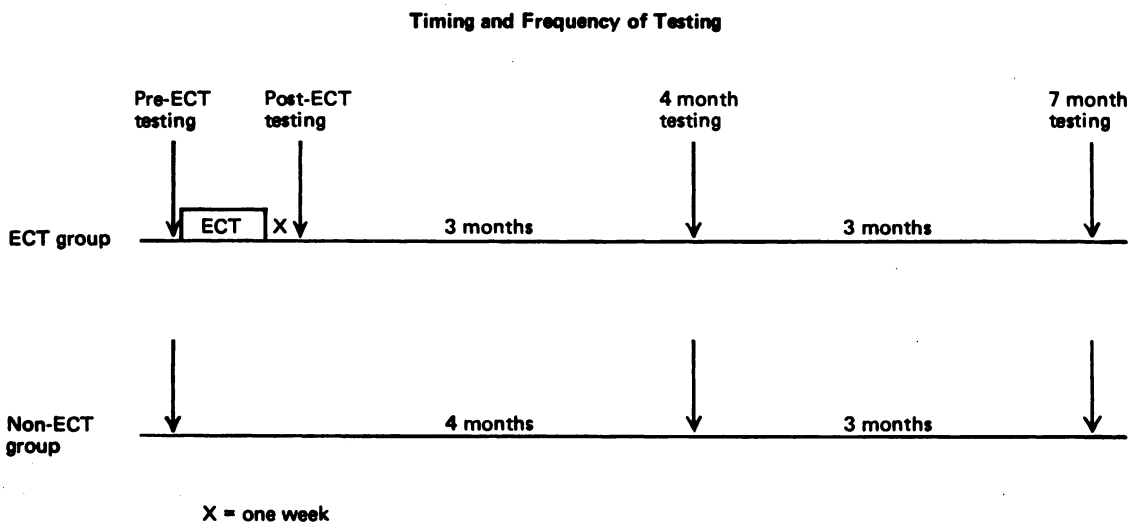


FIG. 1

impaired. Thus, unilateral ECT was just as effective as an antidepressant treatment and appeared to cause virtually no impairment in cognitive functioning.

Amount of ECT given

The ECT group received a mean course of 7.2 treatments. Although the range was wide, one person receiving only two treatments and one as many as twenty, most patients received between 5–8 treatments. We found no correlation between degree of cognitive impairment and number of ECT. There were no complications during treatment involving the study patients, though three patients required a second convulsive stimulus on one occasion each before they had a satisfactory fit.

There were no significant differences between groups in amount of medication taken at any stage. There was a tendency for the ECT group to be on slightly more lithium at four months. At this time the ECT group complained of fewer side effects, particularly headache and dizziness, but the differences were not significant.

Discussion

This study supports the view that ECT when used in everyday clinical circumstances to treat depressed patients does not cause lasting cognitive impairment. None of the very wide ranging battery of tests used to examine all relevant areas of cognitive function showed lasting impairment in the ECT-treated group. The test battery used was more comprehensive than that in any other study to date. Memory functions tested included recall, relearning rate, and recognition, both in the auditory–verbal and visual–spatial modalities. Tests of both immediate and delayed retrieval were used. Both short-term and long-term memory were assessed. Long-term or remote memory was tested for both personal and impersonal facts.

A number of related areas were also tested, such as perceptual aptitude, concentration, short-term predictive planning, choice reaction time (internal information processing speed), discrete peripheral movement speed and fluid movement speed, verbal fluency, speech comprehension, processing and expression, vocabulary and non-verbal problem solving.

We did not use a design involving random allocation to an ECT and non-ECT group. There is good evidence that where accurate matching is required matched group designs are more precise because variance due to random errors is reduced (Ray, 1960). In our opinion it would not have been ethically justifiable to allocate patients randomly to ECT or non-ECT.

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

Had we insisted, subjects would have had only a 50–50 chance of receiving ECT and we would probably only have been referred mild to moderately depressed patients. Random allocation to ECT and simulated ECT would have had the advantage that the psychologist testing cognitive function might have been blind to the treatment given. It would have had the disadvantage that any cognitive impairment due to the anaesthetic or to hypoxia could not have been assessed as this would have been controlled for in the design. We did ensure that cognitive function and level of depression were assessed completely separately. For the first testing neither rater knew which patients were going to receive ECT.

Patients fell into the moderate to severely depressed category with a mean initial Hamilton score of 28 (undoubled). We were able to match initial Hamilton scores closely but it is clear that the ECT group had a slightly different symptom pattern. All the differences that did exist between the two groups at the start of the study were in favour of the non-ECT group.

If no permanent deficit in memory is caused by ECT, why do so many patients complain of both temporary and lasting memory impairment? (Squire and Chase, 1975; Paper I, p. 12). That ECT produces a short-term memory deficit has been shown in many studies, and is also confirmed by the differences between the unilateral and bilateral ECT groups in this report. When the ECT and drug treated groups are compared with the normal control group, both show deficits at both four and seven months on some tests.

Thus patients who complain of memory impairment after treatment for depression are not imagining their disabilities. They are slightly impaired. This may be related to the medication they are taking or to some residual depressive symptoms. The replies to the Broadbent failures questionnaire showed that at follow-up both ECT and non-ECT patient groups complained to an equal extent about memory impairment. It is clear that severe depression profoundly impairs cognitive function and that antidepressant treatments, whether ECT or drug, act in two opposing ways. Their major effect is to reduce impairment by reducing the level of depression. But both also produce a less striking effect in the opposite direction (causing cognitive impairment) although this impairment appears to be reversible.

Finally the results add weight to the view that unilateral ECT to the non-dominant hemisphere causes very little cognitive impairment even in the short-term.

References

BENDEFELDT, F., MILLER, L. L. & LUDWIG, A. M. (1976) Cognitive performance in conversion hysteria. *Archives of General Psychiatry*, **33**(10), 1250–4.

BIDDER, T. G., STRAIN, J. J. & BRUNSCHWIG, L. (1970) Bilateral and unilateral ECT: follow-up study and critique. *American Journal of Psychiatry*, **127**, 737–45.

BRAUN, H. W., RUSSELL, R. W. & PATTON, R. A. (1949) Duration of decrements in learning and retention following electroshock convulsions in the white rat. *Journal of Comparative and Physiological Psychology*, **42/2**, 87–106.

—— BARNES, H. W. & PATTON, R. A. (1957) Effects of electroshock convulsions upon the learning performance of monkeys: IV. Discrimination—reversal learning. *Journal of Comparative and Physiological Psychology*, **50**, 641–3.

BROADHURST, P. L., STONE, C. P. & LAWRENCE, D. H. (1952) The effects of epanutin and electroconvulsive shock on the maze performance of rats. *British Journal of Psychology*, **43**, 85–93.

BROWER, D. & OPPENHEIM, S. (1951) The effects of electroshock therapy on mental functions as revealed by psychological tests. *Journal of General Psychology*, **45**, 171–88.

BROWN, W. L. & SIMPSON, A. D. (1956) Electroconvulsive shock and the learning of visual patterns. *Journal of General Psychology*, **89**, 219–20.

—— & WILBANKS, W. A. (1952) The effect of different periods of electroconvulsive shock on spatial learning. *Journal of General Psychology*, **81/1**, 29–44.

—— & DE LA GARZA, C. O. (1953) The effect of electroconvulsive shock on the anticipatory responses of the rat in a semi-linear maze. *Journal of General Psychology*, **82**, 11–20.

BYRNE, D. G. (1976) Choice reaction times in depressive states. *British Journal of Social Clinical Psychology*, **15**, 149–56.

CARNEY, M. W. P., ROTH, M. & GARSIDE, R. F. (1965) The diagnosis of depressive syndromes and the prediction of ECT response. *British Journal of Psychiatry*, **111**, 659–74.

CRONHOLM, B. & MOLANDER, L. (1964) Memory disturbances after ECT. V. Conditions one month after a series of treatments. *Acta Psychiatrica Scandinavica*, **40/2**, 212–16.

CROWN, S. & CRISP, A. H. (1966) A short clinical diagnostic self-rating scale for psychoneurotic patients. *British Journal of Psychiatry*, **112**, 917–23.

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

DE VIETTI, T. L. & BUCY, C. E. (1975) Recovery of memory after reminder; evidence for two forms of retrieval deficit induced by ECS. *Physiological Psychology*, **3**, 19–25.

GRAHAM-WHITE, J., MERRICK, M. & HERBISON, J. J. M. (1969) Williams Scale for the Measurement of Memory: Test reliability and validity in a psychiatric population. *British Journal of Social Clinical Psychology*, **8**, 141–51.

HALLIDAY, A. M., DAVISON, K., BROWNE, M. W. & KREEGER, L. C. (1968) A comparison of the effects on depression and memory of bilateral ECT and unilateral ECT to the dominant and non dominant hemispheres. *British Journal of Psychiatry*, **114**, 997–1012.

HAMILTON, M. (1960) A rating scale for depression. *Journal of Neurology, Neurosurgery and Psychiatry*, **23**, 56–62.

HEMSI, L. K., WHITEHEAD, A. & POST, F. (1968) Cognitive functioning and cerebral arousal in elderly depressives and dements. *Journal of Psychosomatic Research*, **12**, 145–56.

HESHE, J., RODER, E. & THEILGAARD, A. (1978) Unilateral and Bilateral ECT. *Acta Psychiatrica Scandinavica*, Supp. No. 275.

HOROWITZ, M. W. & STONE, C. P. (1947) The disorganizing effects of electroconvulsive shock on a light discrimination habit in albino rats. *Journal of Comparative and Physiological Psychology*, **40**, 15–21.

JACKSON, B. (1978) The effects of unilateral and bilateral ECT on verbal and visual spatial memory. *Journal of Clinical Psychology*, **34**, 4–13.

KENDRICK D. C. & POST, F. (1967) Differences in cognitive status between healthy, psychiatrically ill and diffusely brain-damaged elderly subjects. *British Journal of Psychiatry*, **113**, 75–81.

KORIN, H., FINK, M. & KWALWASSER, S. (1956) Relation of changes in memory and learning to improvement in electroshock. *Confinia Neurologica*, **16**, 88–96.

LANCASTER, N. P., STEINERT, A. R. & FROST, I. (1958) Unilateral electroconvulsive therapy. *Journal of Mental Science*, **104**, 221–7.

MCGINNIES, E. & SCHLOSBERG, H. (1945) The effects of electroshock convulsions on double alternation leverpressing in the white rat. *Journal of Experimental Psychology*, **35**, 361–73.

MEYER, V. (1959) Cognitive changes following temporal lobectomy for relief of temporal lobe epilepsy. *A.M.A. Archives of Neurological Psychiatry*, **81**, 299–309.

MILLER, E. (1970) The effect of ECT on memory and learning. *British Journal of Medical Psychology*, **43**, 57–62.

MURPHREE, O. D. & PETERS, J. E. (1956) The effect of electroconvulsions, insulin comas and certain chemical agents on fixations in the rat. *Journal of Nervous and Mental Disease*, **124/1**, 78–83.

NEWCOMBE, F. (1969) *Missile Wounds of the Brain*. London: Oxford University Press.

NIELSON, H. C. (1968) Evidence that electroconvulsive shock alters memory retrieval rather than memory consolidation. *Experimental Neurology*, **20**, 3–20.

PORTEUS, S. D. (1965) *Porteus Maze Tests: Fifty Years Application*. Palo Alto, California: Pacific Books.

RATCLIFF, G. (1970) *Aspects of Disordered Perception*. D. Phil Thesis: Oxford University.

RAVEN, J. C. (1958) *Advanced Progressive Matrices*. London: H. K. Lewis.

—— (1962) *Guide to using the Mill Hill Vocabulary Scale*. London: H. K. Lewis.

RAY, W. S. (1960) *An Introduction to Experimental Design*. New York: MacMillan.

RUSSELL, R. W. (1949) Effects of electroshock convulsions on learning and retention in the rat as functions of the difficulty of the task. *Journal of Comparative and Physiological Psychology*, **42**, 137–42.

SCHAIE, K. W. & STOTHER, C. R. (1968) A cross sequential study of age changes in cognitive behaviour. *Psychological Bulletin*, **70**, 671–80.

SIEGEL, P. S. (1943) The effect of electro-shock convulsions on the acquisition of a simple running response in the rat. *Journal of Comparative and Physiological Psychology*, **36**, 61–5.

—— MCGINNIES, E. M. & BOX, J. C. (1949) The runway performance of rats subjected to ECS following nembutal anaesthesia. *Journal of Comparative and Physiological Psychology*, **42**, 417–21.

SNAITH, R. P., AHMED, S. N., MEHTA, S. & HAMILTON, M. (1971) Assessment of the severity of primary depressive illness—Wakefield self-assessment depression inventory. *Psychological Medicine*, **1**, 143–9.

SQUIRE, L. R. & CHACE, P. W. (1975) Memory functions six to nine months after electroconvulsive therapy. *Archives of General Psychiatry*, **32**, 1557–64.

STERN, J. A. (1956) The effect of a series of electroconvulsive seizures on some measures of activity in the male albino rat. *Journal of General Psychology*, **82**, 141–51.

STONE, C. P. (1946a) Effects of electroconvulsive shocks on daily activity of albino rats in revolving drums. *Proceedings of the Society for Experimental Biology and Medicine*, **61**, 150–1.

—— (1946b) Characteristic losses and gains on the Wechsler Memory Scale as applied on psychotic patients before, during, and after ECT. *American Psychologist*, **1**, 245.

TUREK, I. S. & BLOCK, B. (1974) Memory changes with ECT in depression. *British Journal of Clinical Practice*, **28**, 94–5.

WECHSLER, D. (1945) A standardized memory scale for clinical use. *Journal of Psychology*, **19**, 87–95.

WEEKS, D. J. (1979) Do chronic cigarette smokers forget people's names? *British Medical Journal*, *ii*, 1627.

WILCOX, K. W. (1954) *Intellectual functioning as related to electro-convulsive therapy*. Ph.D. Thesis, University of Michigan.

WILLIAMS, L. N. (1959) *The effect of ECS on response flexibility and retention*. Ph.D. Dissertation, University of Washington.

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

ZINKIN, S. & MILLER, A. J. (1967) Recovery of memory after amnesia induced by electroconvulsive shock. *Science*, **155**, 102–4.

APPENDIX

Brief Description of Tests Used

1. *Delayed recall* (*Williams*) (*Graham White* et al, *1969*)
   A test of short-term memory in which nine common objects are presented pictorially for 30 seconds and the subject asked to recall them after a period of 10 minutes, during which time questions are asked concerning their personal remote memories.
2. *Personal remote memories* (*after Bidder* et al, *1970*)
   An interview schedule with 28 items sampling memories from various times in the subject's life, from early childhood to the present.
3. *Famous personalities test 1930's to 1970's* (*Stevens, 1979*)
   A test of impersonal remote memory in which the subject is asked to state how familiar each of 50 names of famous or obscure personalities are to him. Personalities who were particularly famous in one decade only, from the early 1930's onwards have been chosen. Ten fictional names are also randomly presented as a control for 'faking good'.
4. *Logical memory* (*Wechsler, 1945*)
   Immediate reproduction of a brief story read to the subject. The story is divided into 22 word units. The test is a measure of concentration and registration.
5. *Choice reaction time: Decision time and movement time* (*Byrne, 1976*)
   A three-choice reaction timer with two electronically sequenced timers accurate to one millisecond organized so as to separate internal information processing speed (decision time) from physical speed (movement time).
6. *Auditory verbal learning*
   A paired associate verbal learning test in which the subject is required to learn six pairs of nouns that vary along dimensions of associative value, imagery, concreteness, meaningfulness and frequency of usage.
7. *Spatial/Positional learning*
   A task in which the subject is required to learn the specific locations of four differing solid objects in relation to four different pictures exposed simultaneously, each learning trial lasting 30 seconds.
8. *Visual design learning* (*Meyer, 1959*)
   A paired associate learning test in which five pairs of geometric figures, of varying levels of ease of verbalization and random associativeness, have to be learned.
9. *Cube analysis* (*Ratcliffe, 1970*)
   A test of perceptual ability in which the subject is required to count the number of cubes in displays varying from simple to complex. Time and error scores are derived.
10. *Anomalous sentence repetition* (*Newcombe, 1969*)
    Presentation of six increasingly meaningless sentences which have to be immediately reproduced by the subject. The test is particularly sensitive to difficulties in processing speech and differentiates left cerebral hemisphere from right cerebral hemisphere impairment.
11. *Incidental memory*
    Specific questions are asked about the picture/coloured block array which has been presented 45 minutes previously in the Spatial/positional learning test. No prior warning is given. The object is to assess what other information was retained incidental to the original learning task.
12. *Memory sensitivity and response bias*
    The subject is presented with 18 cards, on six of which are the responses learned 50 minutes previously in the Verbal learning task. The other 12 cards are 'noise'. By scoring true and false positive and negative scores for verbal memory sensitivity and response bias can be calculated.
13. *Mill Hill vocabulary scale* (*Raven, 1962*)—*verbal intelligence*
14. *Advanced progressive matrices* (*Raven, 1958*)—*non-verbal intelligence*
15. *Broadbent cognitive failures questionnaire* (*Broadbent, 1979*)
16. *Mental set shifting* (*letter, number sequencing*) (*Bendefeldt* et al, *1976*)
    A test of short-term concentration in which the subject is required to complete three increasingly difficult letter/number sequences until arriving at the end of the alphabet.
    e.g. A1–B2–C3 . . . . ; A2–B4–C6 . . . . ; B3–D6–F9 . . . . etc.
    Time and error scores are derived. Presented only at the four month follow-up.
17. *Face-name test* (*Weeks, 1979*)
    Designed to test complaints from post-ECT patients that they can't put names to faces. The subject is shown 12 pictures of six males and six females for three seconds each. The person's name is read by the experimenter. Each face and name are exposed three times. Ten minutes later, during which time the subject has been actively occupied, the subject is asked to match 12 out of

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press

36 possible names to the correct faces. Presented only at the seven month follow-up.

Rating scales for psychopathology

1. Hamilton rating scale (Hamilton, 1960).
2. Wakefield self-rating scale (Snaith, 1971).
3. Visual analogue daily mood rating scales.
4. Middlesex Hospital questionnaire (Crown and Crisp, 1966).
5. Newcastle diagnostic index (Carney *et al*, 1965).

C. P. L. Freeman, M.B., Ch.B., M.Phil., M.R.C.Psych., *Lecturer, University Department of Psychiatry, (Royal Edinburgh Hospital), Morningside Park, Edinburgh EH10 5HF*

D. J. Weeks, B.A. Hons., M.Phil., *Senior Clinical Psychologist, Royal Victoria Hospital, Comely Bank, Edinburgh EH4 2DN*

R. E. Kendell, M.D., F.R.C.P., F.R.C.Psych., *Professor of Psychiatry, University Department of Psychiatry, (Royal Edinburgh Hospital), Morningside Park, Edinburgh EH10 5HF*

Received 31 January 1980; revised 28 March 1980

https://doi.org/10.1192/bjp.137.1.26 Published online by Cambridge University Press