file: ECT: mem 6088

Brit. J. Psychiat. (1982), **141**, 608–613

Comparison of Unilateral and Bilateral ECT: Evidence for Selective Memory Impairment

D. FROMM-AUCH

Summary: Review of studies from the past 16 years employing quantitative measurement of memory functions before and after ECT revealed the following trends: impairment of non-verbal memory functions after less than five unilateral non-dominant ECTs; improvement of non-verbal memory functions after five or more unilateral non-dominant ECTs; no change or improvement of verbal memory functions with unilateral non-dominant ECT; consistent impairment of verbal functions with unilateral dominant ECT, and impairment of both verbal and non-verbal functions with bilateral ECT. The relative lack of impairment in memory functions with unilateral non-dominant ECT is consistent with the theory of asymmetrical hemispheric disorganization in affective disorders, and supports the choice of unilateral non-dominant ECT over bilateral or unilateral dominant ECT in the treatment of depression.

In the early years of electroconvulsive therapy (ECT), loss of memory was believed to be an integral part of the therapeutic effect, and hence the relationship between ECT and memory impairment was thought to be positive. Research has since demonstrated that clinical improvement is not correlated with memory deficits (Fink, 1974; Korin *et al*, 1956), and that unilateral non-dominant ECT, although of equal efficacy to bilateral ECT in ameliorating depression, produces less cognitive and memory impairment (Lancaster *et al*, 1958; Martin *et al*, 1965; Levy, 1968; Squire and Slater, 1978; d'Elia and Raotma, 1975; Zinkin and Birtchnell, 1968; Dornbush *et al*, 1971; for review see Harper and Weins, 1975) and a lower percentage of abnormal EEG recordings at four days after treatment (Sutherland *et al*, 1969).

Recent research (Kronfol *et al*, 1978) has further suggested that rather than impairment, selective improvement occurs on tasks more dependent upon non-dominant hemisphere processing, such as visuo-spatial problems. These researchers studied 18 depressed patients neuropsychologically, prior to and after the first and eighth treatment of unilateral ECT. They found that non-dominant hemispheric functions, which were more frequently abnormal in the neuropsychological tests before ECT, improved with either dominant (DOM) or non-dominant (NDOM) ECT when depression was ameliorated. On this basis, it was concluded that in depression, non-dominant hemispheric functions are initially disturbed and ECT, instead of being deleterious to these functions, tends to improve them. Kronfol and his colleagues did not include a bilateral ECT group and therefore selective improvement in non-verbal functions with bilateral ECT was not examined.

At least three interesting questions arise from this research: Have other studies demonstrated a selective improvement in non-verbal functions with unilateral ECT? Is this trend demonstrated following bilateral ECT? How do verbal memory functions covary with bilateral and unilateral ECT? To consider these questions, the present paper is a review of previously published research which investigated quantitative memory changes in samples of psychiatrically depressed patients, following bilateral and unilateral ECT.

Method

A Medlars II (1967) search covering the last 16 years was performed, using the key words 'electroconvulsive therapy' and 'psychological tests'. Inclusion criteria for studies were: that subjects were psychiatric patients with a diagnosis of depression; that quantitative measurement of memory or learning effects was carried out both before and after ECT; and that there was comparison of bilateral with unilateral ECT, or of unilateral DOM with unilateral NDOM ECT. Some of the earlier studies using the Wechsler Memory Scale (WMS) do not publish the subtest scores separately, and hence the verbal and non-verbal performance respectively could not be determined. In those cases, if the WMS quotient improved after ECT, both the

verbal and non-verbal portions are assumed to have improved.

The relationship between the following factors and test results was examined—the time between last ECT and testing, the number of ECTs and the percentage of females within each study. Attenuation of post-ECT confusion and depression may be indicated by the first two factors respectively, while gender may be important in the ECT response and laterality effect. The number of subjects within each study was also examined, so that equal weight would not be applied for each result.

Results

Twenty-two studies fulfilled the inclusion criteria (Table I): most of them compared either unilateral DOM and NDOM ECT or bilateral with NDOM ECT. The most striking trend is that non-verbal memory functions, relative to pre-ECT testing, which appear to deteriorate with 1–4 NDOM ECTs, significantly improve after a minimum of five NDOM ECTs (lower right side of Table). Verbal memory remains unchanged or significantly improves with NDOM ECT, regardless of the number of treatments, in all but two studies (Strain *et al*, 1968; Fromholt

TABLE I

Post-treatment changes in memory functions following bilateral and unilateral ECT

Research articles	n	Females	Latency to test time post-ECT	No. of ECTs	Bilateral ECT		Unilateral dominant ECT		Unilateral non-dominant ECT	
					Verbal	Non-verbal	Verbal	Non-verbal	Verbal	Non-verbal
Berent *et al* (1975)	24	100%	5 hrs.	1	—	—	x	n.s.	n.s.	x
Annett *et al* (1974)	32	84%	½ hr.	1	—	—	x	n.s.	n.s.	n.s.
Zinkin *et al* (1968)	102	74%	0–3 hrs.	1	x	x	—	—	n.s.	n.s.
d'Elia *et al* (1976)	20	75%	3 & 6 hrs.	2–3	—	—	x	n.s.	n.s.	x
Squire & Slater (1978)	72	74%	6–10 hrs.	1, 3 & 5	x	x	—	—	n.s.	x
Costello *et al* (1970)	30	67%	28–31 hrs.	4	x	—	x	—	0	—
Halliday *et al* (1968)	52		4 days	4	0	x	x	n.s.	0	x
Robertson & Inglis (1978)	48	55%	10–14 hrs.	4	x	x	—	—	0	x
Robertson & Inglis (1973)	20	70%	10–14 hrs.	4	x	x	—	—	0	x
Dornbush *et al* (1971)	40		24 hrs.	4–5	x	n.s.	—	—	n.s.	n.s.
Strain *et al* (1968)	106	71%	36 hrs.	4–12	x	n.s.	—	—	x	n.s.
Fraser & Glass (1980)	29	76%	24 hrs.	5	n.s.	0	—	—	n.s.	n.s.
Cohen *et al* (1968)	24	100%	5–8 hrs.	5	x	x	x	n.s.	n.s.	x
Zamora *et al* (1965)	28	43%	30–36 hrs.	5	—	—	x	—	0	—
Small *et al* (1972)	19	63%		5	—	—	x	n.s.	0	0
Cannicott & Waggoner (1967)	24		2 hrs.	5	x	—	—	—	n.s.	—
Fromholt *et al* (1973)	100	61%	24 hrs.	6	x	0	—	—	x	0
Jackson (1978)	34	0%	½ hr.	6	x	x	x	n.s.	n.s.	x
Sutherland *et al* (1969)	57		36 hrs.	6	x	0	x	0	0	0
Weeks *et al* (1980)	51	67%	1 week	5–8	n.s.	n.s.	—	—	0	0
Kronfol *et al* (1978)	18	66%	5 hrs.	8	—	—	n.s.	0	n.s.	0
Martin *et al* (1965)	40		24 hrs.	10	x	x	—	—	0	0

x = Significant decrease in post-ECT performance of at least $P < .05$

0 = Significant increase in post-ECT performance of at least $P < .05$

— = Functions not assessed

n.s. = Non-significant change

et al, 1973). Bilateral and DOM ECT generally results in a decreased or non-significant change for both verbal and non-verbal functions. Improvement of verbal memory after bilateral ECT is reported in one study (Halliday *et al*, 1968), while improvement of non-verbal memory occurs in three studies employing bilateral ECT (Fraser and Glass, 1980; Fromholt *et al*, 1973; Sutherland *et al*, 1969) and in two studies employing DOM ECT (Sutherland *et al*, 1969; Kronfol *et al*, 1978). When they occur, positive changes in verbal functions are found after a minimum of four treatments (bilateral and NDOM ECT only), while positive changes in non-verbal functions are obtained after a minimum of five treatments (bilateral, DOM and NDOM ECT). Verbal memory functions are not found to improve with DOM ECT, in contrast to improvement of non-verbal functions with NDOM ECT, and less consistently, with bilateral and DOM ECT.

Of the 91 group performance measures in Table I (30 for bilateral ECT; 20 for DOM ECT, and 41 for NDOM ECT), ten are exceptions to the following trends: impairment of both verbal and non-verbal functions with bilateral ECT (Halliday *et al*, 1968; Fraser and Glass, 1980; Fromholt *et al*, 1973; Sutherland *et al*, 1969); impairment of non-verbal functions with DOM ECT (Sutherland *et al*, 1969; Kronfol *et al*, 1978); no change or improvement in verbal functions with NDOM ECT (Strain *et al*, 1968; Fromholt *et al*, 1973), and improvement in non-verbal functions after a minimum of five NDOM ECT treatments (Cohen *et al*, 1968; Jackson, 1978).

Two other studies fulfilled the inclusion criteria, but the results are not comparable to the findings reported above, due to the research paradigm used (Cronin *et al*, 1970) or the type of data analysis (Bidder *et al*, 1970). Nevertheless, both of these studies demonstrate verbal memory loss with bilateral ECT and non-significant change in non-verbal memory with unilateral NDOM and bilateral ECT.

The latency to test time after ECT does not appear to influence these findings, since the time varies from .5 hours to 100 hours within the 1–5 treatment category. However, it does appear important for the five-or-more treatment group of studies. One of two studies which does not show improvement of non-verbal functions after six unilateral NDOM ECT (Jackson, 1978) tested the patients half an hour after the sixth ECT treatment. This is also the only study which has an all-male sample. The lowest percentage of females in the studies for which this information is available is 43 per cent, with a mean of 73 per cent.

Discussion

Despite differences in methodology, treatment techniques and behavioural tests, several trends emerge from the results reviewed. These are: impairment of non-verbal functions with less than five NDOM ECTs; improvement of non-verbal functions after a minimum of five NDOM ECTs; unchanged or improved verbal memory functions with NDOM ECT; impairment of verbal functions with DOM ECT; and impairment of verbal and non-verbal functions with bilateral ECT.

Improvement of non-verbal functions with NDOM ECT after five or more treatments suggests that attentuation of cognitive deficits parallels amelioration of depression. With fewer treatments, and presumably less attenuation of depression, the disruptive effects of the ECT predominate, and selective impairment rather than improvement is shown. This evidence is consistent with the theory of asymmetrical dysfunction in affective disorders. On the basis of a synthesis of findings from many diverse areas within neuroscientific research, Flor-Henry (1973; 1976; 1978a, b; 1979) concludes that the neural subtrate of emotion is predominately non-dominant and that the depressive phase of the manic-depressive syndrome is manifested when cerebral disorganization is more pronounced for the non-dominant hemisphere.

The findings of others, however, are not consistent with this. A dysfunctional left hemisphere has been implicated in at least some forms of depression (e.g. Hommes and Panhuysen, 1971). The asymmetry of emotional response found in humans, i.e. strong emotion with right hemisphere activation and inhibition of the left hemisphere (Gainotti, 1972; Perria *et al*, 1961; Rossi and Rosadini, 1967; Ross and Mesulam, 1979; Dimond *et al*, 1976) also fits within this theoretical framework. In depression, an imbalance of hemispheric activation, presumably due to perturbation of the right hemisphere, normalizes following ECT, which in turn results in decreased depressive symptomatology and concurrent selective improvement of visuospatial functions.

Exceptions to the above five major trends are reported in eight studies. Halliday *et al* (1968) found an improvement in verbal learning with four bilateral ECTs, while Fraser and Glass (1980), Fromholt *et al* (1973) and Sutherland *et al* (1969) found an improvement in non-verbal functions after five, six, and six bilateral ECTs respectively. It is of interest that the five studies with the largest number of subjects show either a non-significant change or else improvement of non-verbal functions, after a minimum of five bilateral ECTs. Similarly, Sutherland *et al* (1969) and Kronfol *et al* (1978) found selective improvement of non-verbal functions after six and eight DOM ECTs respectively. This improvement in non-verbal memory function with DOM and bilateral ECT, although less consistent, is similar to the trend noted after a minimum

of five NDOM ECTs, and therefore may also be reflective of differential improvement of memory function with attenuation of depression.

Strain *et al* (1968) and Fromholt *et al* (1973), investigating 106 and 100 subjects respectively, were the only researchers to find a decrease in verbal memory with NDOM ECT. Strain *et al* (1979) found that paired Associate Learning test scores were significantly reduced ($P < .001$) from pre-ECT levels, for both the bilateral and unilateral ECT groups, although the bilateral group showed more impairment ($P < .05$). Similarly, Fromholt *et al* (1973), in an analysis of intra-group changes for the NDOM and bilateral ECT groups, showed reduced scores on Associate Learning ($P < .01$) from the WMS. It is difficult, however, to reconcile these data with those of other researchers; the divergent findings are based on the same or similar verbal learning tasks, i.e. paired associate word learning, similar latency to test time, number of ECTs, placement of electrodes, and percentage of females. One possible explanation is based on handedness, since the handedness of the sample is not indicated by Fromholt *et al*. A sufficient number of patients with primarily right hemisphere language functions could have influenced the group results; i.e. unilateral ECT to the hemisphere primarily responsible for speech would result in reduced verbal memory scores, as illustrated by the results following DOM ECT.

Cohen *et al* (1968) and Jackson (1978) are the only authors who found a decrease in non-verbal memory with five and six NDOM ECTs respectively. The first, although finding a decrement in the retention of both forms and words across DOM, NDOM, and bilateral ECT groups, conclude that the ECT-produced decrements were not as large for the Forms as for the Words. In addition, the decrement shown on Words by the DOM ECT groups exceeded that shown on Forms by the NDOM ECT groups. This is consistent with the trend appearing in the other studies reviewed in this paper. However, the reason for the decrement as opposed to improvement is not clear. Latency to test time and the gender ratio of the sample may have influenced the results of Jackson (1978), who tested his all-male patient sample half an hour after the treatment. Contamination of the results with post-ECT confusion may account for the negative findings. The evidence from numerous demographic studies indicates that the rate of depression is much higher for females than males, in the order of 2 or 3:1 (Baron, 1981; Polonio, 1966; Rosenthal, 1970; McCabe, 1975), making the sample in Jackson's study atypical of depressed patients.

Despite these exceptions, the studies reviewed suggest that unilateral NDOM ECT produces less impairment of verbal memory, compared to unilateral DOM or bilateral ECT, a conclusion drawn by other researchers. An additional trend suggests selective improvement of non-verbal functions with NDOM ECT after a minimum of five treatments, a finding which is less consistent for DOM ECT and bilateral ECT. The relative lack of impairment in memory functions with NDOM ECT, coupled with the results from the last 20 years indicating the equal efficacy of NDOM and bilateral ECT treatment (for review see d'Elia and Raotma, 1975), cogently argues for the choice of unilateral NDOM ECT over bilateral ECT, in direct contrast to much of the present practice in Great Britain (Pippard and Ellam, 1981).

References

Annett, M., Hudson, P. T. & Turner, A. (1974) Effects of right and left unilateral ECT in naming and visual discrimination analyzed in relation to handedness. *British Journal of Psychiatry*, **124**, 260–4.

Baron, M. (1981) Genetic models of sex effect in unipolar affective illness. *Acta Psychiatric Scandanavica*, **64**, 85–91.

Berent, S., Cohen, R. & Silverman, A. (1975) Changes in verbal and nonverbal learning following a single left or right unilateral electroconvulsive treatment. *Biological Psychiatry*, **10**, 95–100.

Bidder, T. G., Strain, J. J. & Brunschwig, L. (1970) Bilateral and unilateral ECT: Follow-up study and critique. *American Journal of Psychiatry*, **127**, 37–45.

Cannicott, S. M. & Waggoner, R. W. (1967) Unilateral and bilateral electroconvulsive therapy. *Archives of General Psychiatry*, **16**, 229–32.

Cohen, B., Noblin, C. & Silverman, A. (1968) Functional asymmetry of the human brain. *Science*, **162**, 475–7.

Costello, C. G., Belton, G. P., Abra, J. C. & Dunn, B. E. (1970) The amnestic and therapeutic effects of bilateral and unilateral ECT. *British Journal of Psychiatry*, **116**, 69–78.

Cronin, D., Bodley, P., Potts, L., Mather, M., Gradner, R. & Tobin, J. (1970) Unilateral and bilateral ECT: A study of memory disturbance and relief from depression. *Journal of Neurology, Neurosurgery and Psychiatry*, **33**, 705–13.

d'Elia, G. & Raotma, H. (1975) Is unilateral ECT less effective than bilateral ECT? *British Journal of Psychiatry*, **126**, 83–9.

—— Lorentzon, S., Raotma, H. & Widepalm, K. (1976) Comparison of unilateral dominant and non-dominant ECT on verbal and non-verbal memory. *Acta Psychiatrica Scandinavica*, **53**, 85–94.

Dimond, S. J., Farrington, L. & Johnson, P. (1976) Differing emotional responses from right and left hemispheres. *Nature*, **261**, 690–2.

Dornbush, R., Abrams, R. & Fink, M. (1971) Memory changes after unilateral and bilateral convulsive therapy (ECT). *British Journal of Psychiatry*, **119**, 75–8.

FINK, M. (1974) Induced seizures and human behavior. In *Psychobiology of Convulsive Therapy* (eds. M. Fink, S. Kety *et al*). Washington, D.C.: V. H. Winston.

FLEMINGER, J. J., HORNE, DEL, NAIR, N. P. & NOTT, P. N. (1970) Differential effect of unilateral and bilateral ECT. *American Journal of Psychiatry*, **127**, 430–6.

FLOR-HENRY, P. (1973) Psychiatric syndromes considered as manifestations of lateralized temporal-limbic dysfunction. In *Surgical Approaches in Psychiatry* (eds. L. V. Laitinen and K. E. Livingston). Lancaster: Medical and Technical Publishing.

—— (1976) Lateralized temporal-limbic dysfunction and psychopathology. *Annals of the New York Academy of Sciences*, **280**, 777–95.

—— (1978a) Gender, hemispheric specialization and psychopathology. *Social Science and Medicine*, **12B**, 155–62.

—— (1978b) The endogenous psychoses: A reflection of lateralized temporal-limbic dysfunction. In *The Limbic System Concept* (eds. K. Livingston and O. Hornykiewicz). New York: Plenum Press.

—— (1979) On certain aspects of the localization of the cerebral systems regulating and determining emotion. *Biological Psychiatry*, **14**, 677–98.

FRASER, R. M. & GLASS, I. B. (1980) Unilateral and bilateral ECT in elderly patients. *Acta Psychiatrica Scandinavica*, **62**, 13–31.

FROMHOLT, P., CHRISTENSEN, A. & STROMGRAN, L. (1973) The effects of unilateral and bilateral electroconvulsive therapy on memory. *Acta Psychiatrica Scandinavica*, **49**, 466–78.

GAINOTTI, G. (1972) Emotional behavior and hemispheric side of lesion. *Cortex*, **8**, 41–55.

HALLIDAY, A., DAVISON, K., BROWNE, M. & KREEGER, L. (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.

HARPER, R. G. & WIENS, A. N. (1975) Electroconvulsive therapy and memory. *Journal of Nervous and Mental Disease*, **161**, 245–54.

HOMMES, O. R. & PANHUYSEN, L. H. H. M. (1971) Depression and cerebral dominance: A study of bilateral intracarotid amytal in eleven depressed patients. *Psychiatrica Neurolgia and Neurochirurigia*, **74**, 259–70.

JACKSON, B. (1978) The effects of unilateral and bilateral ECT on verbal and visual spatial memory. *Journal of Clinical Psychology*, **34** (1), 4–13.

KORIN, H., FINK, M. & KWALWASSER, S. (1956) Relation of changes in memory and learning to improvement in electroshock. *Confinia Neurology*, **16**, 88–95.

KRONFOL, Z., HAMSHER, K. DES., DIGRE, K. & WAIZIRI, R. (1978) Depression and hemispheric function: Changes associated with unilateral ECT. *British Journal of Psychiatry*, **132**, 560–7.

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

LEVY, R. (1968) Clinical evaluation of unilateral electroconvulsive therapy. *British Journal of Psychiatry*, **114**, 459–63.

MCCABE, M. S. (1975) Demographic differences in functional psychoses. *British Journal of Psychiatry*, **127**, 320–3.

MARTIN, W., FORD, H., MCDANALD, E. & TOWLER, M. (1965) Clinical evaluation of unilateral ECT. *American Journal of Psychiatry*, **121**, 1087–90.

MEDLARS II (1967) National Library of Medicine Interactive Retrieval Service, Bethesda, Maryland.

PERRIA, L., ROSADINI, G. & ROSS, G. F. (1961) Determination of side of cerebral dominance with amobarbital. *Archives of Neurology*, **4**, 173–81.

PIPPARD, J. & ELLAM, L. (1981) Electroconvulsive treatment in Great Britain. *British Journal of Psychiatry*, **139**, 563–8.

POLONIO, P. (1966) L'analyse structural des psychoses endogenes au Portugal. In *Proceedings of the IV World Congress of Psychiatry*, Springfield: C. Thomas.

ROBERTSON, A. & INGLIS, J. (1973) Cerebral asymmetry and ECT. Reprinted from the Proceedings, 81st Annual Convention, American Psychological Association, pp 431–2. APA: 1200 17th Street NW, Washington DC, 20036, USA.

—— —— (1978) Memory deficits after electroconvulsive therapy: Cerebral asymmetry and dual-encoding. *Neuropsychologia*, **16**, 179–87.

ROSENTHAL, D. (1970) *Genetic Theory and Abnormal Behavior*. New York: McGraw-Hill.

ROSS, E. D. & MESULAM, M. M. (1979) Dominant language functions of the right hemisphere. *Archives of Neurology*, **35**, 144–8.

ROSSI, G. F. & ROSADINI, G. (1967) Experimental analysis of cerebral dominance in man. In *Brain Mechanisms Underlying Speech and Language* (eds. C. H. Millikan and F. L. Karley). New York: Grune & Stratton.

SMALL, I. F., SMALL, J. G., MILSTEIN, V. & MOORE, J. E. (1972) Neuropsychological observations with psychosis and somatic treatment. *Journal of Nervous and Mental Disease*, **155**, 6–13.

SQUIRE, L. R. & SLATER, P. C. (1978) Bilateral and unilateral ECT effects on verbal and nonverbal memory. *American Journal of Psychiatry*, **135**, 1316–20.

STRAIN, J. J., BRUNSCHWIG, L., DUFFY, J. P., AGLE, D. P., ROSENBAUM, A. L. & BIDDER, T. G. (1968) Comparison of therapeutic effects and memory changes with bilateral and unilateral ECT. *American Journal of Psychiatry*, **125**, 294–304.

SUTHERLAND, E., memory and and bi-temp **115**, 1059–64
WEEKS, D., FREE ECT: III. E *of Psychiatry*

Delee From

(*Received 7 D*

SUTHERLAND, E., OLIVER, J. & KNIGHT, D. (1969) EEG, memory and confusion in dominant, non-dominant, and bi-temporal ECT. *British Journal of Psychiatry*, **115**, 1059–64.

WEEKS, D., FREEMAN, C. P. L. & KENDELL, R. E. (1980) ECT: III. Enduring cognitive deficits? *British Journal of Psychiatry*, **137**, 26–37.

ZAMORA, E. & KAELBLING, R. (1965) Memory and electroconvulsive therapy. *American Journal of Psychiatry*, **122**, 546–54.

ZINKIN, S. & BIRTCHNELL, J. (1968) Unilateral electroconvulsive therapy: Its effects on memory and its therapeutic efficacy. *British Journal of Psychiatry*, **114**, 973–88.

Delee Fromm-Auch, M.A., *Certified Psychologist, Alberta Hospital, Box 307, Edmonton, Alberta, T5J 2J7, Canada*

(*Received 7 December 1981; revised 23 February 1982*)