A CLINICAL PSYCHOLOGICAL STUDY OF ELECTRIC CONVULSANT THERAPY

by

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PERSONAL INTRODUCTION

The work reported in this thesis was begun at Manchester and completed in Glasgow. Thus I can acknowledge two influences - that of Professor E.W. Anderson and his phenomenological approach and the widely based eclecticism of Professor T. Ferguson Rodger. My approach to clinical psychology is enriched as a result of these contacts and is much fuller and more satisfying than the professional role which many of my colleagues have undertaken or have been allotted.

However, the fact that I have chosen to concern myself with a physical method of treatment has arisen from purely personal interests. Since my entry into the field the use of Electric Convulsant Therapy in psychiatric illness has interested me and intrigued me with the number of problems that its application can pose. In this thesis some of these problems will be raised and discussed. The issues lead me beyond what other psychologists have taken to be the relevant aspects of this treatment, viz. its effects on cognitive functions. For me E.C.T. has much wider implications and provides a setting for a discussion of the field of psycho-physiology.

The approach is clinical in that it starts from the observation/

observation of patients being treated for their illnesses, and does not seek to go beyond the clinical situation. It involves as much objectivity as my respect for patients and clinical problems will allow me detachment. The reports of the investigations follow the conventional rules and statistical methods have been employed. Statistics are used, however, simply as a means of making part of an argument 'public' and not as an end or proof. This I take to be the proper function of statistical methods in the clinical field where so many of the issues demand what is properly search rather than research.

In the discussion and formulation of points reference is made to many workers in the field. Acknowledgement is made by the convention of quoting the author's name and year of publication in the text, with fuller reference to the source appearing in the bibliography of references. The interpretation of these author's works is original and does not necessarily accord with their own views or purposes.

There are many people to thank: Professor E.W. Anderson, Drs. Rawnsley and Scott, Mr. J.C. Kenna and others in the Department of Psychiatry, University of Manchester; Professor T. Ferguson Rodger, Dr. J. Roy and others in the Department of Psychological Medicine, University of Glasgow, and Miss B. Polley and Miss A. Logan for their secretarial help. I have also to record my gratitude for the tolerant co-operation of many patients.

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HISTORY OF CONVULSION THERAPY

Origins and Early History

There are many instances cited in the early history of psychiatry of how the production of sudden and sometimes aggressive environmental changes have proved to be effective in the relief of mental illness. Among the deliberate attempts to induce "shock" or fright as a therapeutic measure are found ducking, sudden immersion in cold water, using large doses of alcohol and blood letting. Toxic substances were also used to produce shock, for example, cyanide and hellebore (Zilboorg, 1941). One justification that could be offered for this approach was the Hippocratic observation that an organic physical disease supervening on mental illness led to an abatement of the psychosis. Thus it could be argued that the creation of "controllable illnesses" of a physical kind would lead to pathological states in which the restitutive bodily processes might benefit the mental disorder. However, it is impossible to trace any such consistent theoretical basis for the therapeutic use of shock. The rationale has varied with the prevailing philosophy and practice.

In Roman times Titus advocated flogging as a cure for insanity. Early in the Christian era Celsus recommended starving/

starving, chains and flogging as a method of stimulating the appetite of patients. He claimed that such treatment "refreshed the memory" in some cases. Aretaeus, a contemporary of Galen, advised bleeding to relieve the liver in melancholy and purging by means of aloes (Henderson and Gillespie, 1946). It was thought that lunatics were possessed by evil spirits and trephining of the skull was often carried out to release them (Osler, 1921). Later in the middle ages this medical exorcism was stopped and the priests took over the treatment of mental illness by means of various religious rites (Zilboorg, 1941). Early in the 16th century Paracelsus gave camphor by mouth to produce convulsions and to cure lunacy (Bennett, 1943), but the treatment achieved little popularity at the time. Van Helmont in 1707 advocated plunging patients into cold water because he had heard of a Dutch carpenter who was cured from insanity by accidentally falling into a river (Diethelm, 1939). So impressed were many workers by such tales of recovery from insanity by sudden accidental shock that they contrived various gadgets to produce such "accidents" within their hospital. Gadelius (1933) relates how in Scandinavia one hospital provided a boat in which the patient, while being peacefully rowed on an ornamental lake by an attendant, could be/

be suddenly precipitated into the water in an effort to cure him. Oberndorff (1938) quotes from the "Tentamen therapeuticum de animi perturbationibus" written by an unnamed student of medicine in France in 1783. This book contains a detailed discussion of the merits of ducking, and a description of a rotating chair. It also includes an account of how Boerhaave, the famed Dutch clinician and enlightened medical scientist, "cured" an outbreak of convulsions in an orphanage at Haarlem by heating an iron rod to glowing heat and threatening to burn to the bone the next child who had a convulsion. Burrows (1828) gives a full description of the methods of treatment for mental disorders which were popular in the 18th and early 19th centuries. Venesection, local bleeding by leeches, cupping, purging, blistering, all had their advocates. He also describes the therapy of swinging and gyration in which the patient was rotated in a swivel chair until vomiting and collapse were induced. Another interestingly named contrivance was the "tranquilliser of Rush" which was in effect a suspended bed in which the patient was swung until "the blood was driven from his brain and he went to sleep".

Harms (1956) traces the origins of electrical treatment to the beginnings in 1740 of a series of biennial reports on Electricity and Medicine by l'Academie Royale des Sciences in/

in France. In this journal in 1755 Dr. J.B. le Roy reports the cure of a blind person after three shocks and other "guerisons" are listed from all over Europe. However, by the end of this century electrotherapy of this sort had fallen into disuse. This period saw important technical advances in electricity and it may have been dissatisfaction with the imprecision of the therapeutic applications in the light of the new knowledge that caused a swing away from electrical to pharmacological methods of treatment.

Burrows, for example, prescribed camphor in large doses... "in a case of insanity where two scruples were exhibited it produced a fit and a perfect cure followed". The history of the use of camphor in the treatment of mental disorders is outlined by Kennedy (1940). Leopold von Auenbrugger in 1764 advised that in "mania virorum" a mixture containing camphor should be taken every two hours day and night. Weickhardt in 1798 advised that in cases of lunacy camphor should be used to the point of producing vertigo and epileptic fits. Szekeres in 1851 prescribed doses of camphor, increasing by 5 gr. until 60 gr. were given daily, this dosage to be continued until fits appeared. After the fits he claimed patients became lucid and their recovery would commence. With the discovery of ether as an anaesthetic in 1846, etherisation came/

came into fashion as a method of treatment in psychiatry. It was much used between 1849 and 1860 not only in Europe but in America where it was reported to be "valuable in acute excitements and depressive agitations, especially with marked fear and outbursts of panic" (Diethelm, 1939).

By the latter half of the 19th century with the knowledge of galvanic and faradic electricity and the use of the Leyden jar to vary strength and duration of stimulus, electrotherapy was re-introduced and pharmacological methods of treatment began in their turn to be replaced by electrical forms of treatment. As in other fields of medical treatment by electricity it was felt the application of draughts of electric current, particularly when derived from impressive apparatus, was of great importance in the treatment of mental disorders. Even as early as 1853 Huff is quoted as saying that "no nervous affection whatever should be regarded as incurable until electricity has in some form been tried" (Androp, 1941). Even earlier, Burrows (1828) had indicated the value of the application of "galvanism" to the bowels in cases of melancholy. Allbutt in 1872 is quoted by Caplan (1945) as having used a galvanic current from a modification of the Daniell cell, passing this current through the patient's head for 10 minutes and thereby achieving tranquillisation of the patient. About this time sufficient use had been made/

made of electrotherapy to allow Morriz Benedikt, an Austro-Hungarian neurologist, to compile a two-volume work on "Elektrotherapie" giving precise electrotherapeutic prescriptions for all known neuropathological states (Harms, 1956). However, as Androp (1941) suggests, the results of such therapy gradually waned until by the beginning of this present century the treatment was no longer popular.

Once more the pendulum began to swing back in favour of drug treatment and in 1901 Wolf recommended prolonged sleep by means of Trional as a method of psychiatric therapy. Epifanio in 1916 also reported favourably on this therapy which he carried out with the aid of phenobarbitone (Diethelm, 1939). In 1922 Klüsi followed up his work on prolonged sleep by introducing prolonged narcosis with Somnifaine. Klüsi is conventionally recognised to be the instigator of the modern period of shock therapy, and it is of more than passing interest to notice that Klüsi's contribution occurred in the same year as Wagner-Jauregg described his malaria treatment of general paralysis of the insane.

Modern Physiodynamic Therapies.

Electrical means of shock therapy were to be re-introduced in psychiatry but only after a significant period during which pharmacological agents were used. Manfred Sakel (1938)/

(1938), using his experience in the treatment of drug addicts by insulin, thereby minimising withdrawal effects, began to treat mental illnesses by insulin-produced hypoglycaemia. In 1933 he began to treat schizophrenia by this method. Around this time too, the use of metrazol, a synthetic compound related to camphor, was advocated by Nyiro and Jablonsky. These workers deliberately sought to produce convulsions in their schizophrenic patients. The rationale for this procedure was that Glaus in 1931 had reported that, contrary to Kraepelin's and to Bleuler's views, the combination of schizophrenia and epilepsy was rare. Glaus found that out of 6,000 schizophrenics only eight had had fits and that four of these eight recovered shortly after their fits. Other contemporary reports confirmed this suggested antagonism between schizophrenic catatonia and epilepsy.

Von Meduna (1958) gives an account of his own work in this field at this time. Working in a psychiatry dominated by Virchovian concepts he was concerned to reveal the brain pathology of schizophrenia. Fifteen years of examination of schizophrenic brains had yielded the observation that in schizophrenia destroyed nerve tissue was not replaced by the glia system. Interest in epilepsy arose because it was known that in this condition glia proliferation occurred. The beneficial/

beneficial effect of epilepsy on schizophrenia currently being claimed reminded Meduna of how induced malaria had a curative effect on general paralysis of the insane.

With these facts in mind Meduna sought a convenient method of producing epileptic attacks. In his search he was influenced by a number of fortuitous circumstances; by experiment on guinea pigs he was able to satisfy himself that camphorated oil when injected could produce the convulsion with no apparent subsequent ill-effects. On January 23rd, 1934, he induced the first convulsion in a patient by the intramuscular injection of 25% camphor in olive oil. He described how at the end of this successful treatment he was so distressed himself that he had to be supported to his room by nurses. It was another of his "fruitful errors" that led him to use the substance "Cardiazol" which had been wrongly advertised by the manufacturers as being water soluble camphor when in fact it had nothing to do with camphor.

More recent work has not confirmed the suggested antagonism between epilepsy and schizophrenia (e.g. Alexander, 1952; Katzenelbogen, 1940). Yde, Lohse and Faurbye (1941) investigated 715 cases of schizophrenia and found 20 patients who suffered from convulsive attacks, five of whom were established epileptics. This represents an incidence of about twice the expected chance incidence for epilepsy.

Hoch/

Hoch (1943) has also indicated a positive tendency for schizophrenia and epilepsy to be associated. More recently Bartlett (1957), in an effort to clarify the relationship between chronic psychosis and epilepsy, studied the case records of all patients encountered in two hospitals over a five-year period with a diagnosis of psychosis following on epilepsy and with the continued diagnosis of epilepsy and psychosis. He found no significant evidence to suggest that schizophrenia occurs more or less frequently in epileptics than in the general population. In general, the apparent antagonism between epilepsy and schizophrenia seems to have been fostered by the diagnostic convention of not specifying the form of functional disorder accompanying epilepsy. Generally the term "psychosis due to convulsive disorder" or "epilepsy with behaviour disorder" was used which did not allow any indication that the illness was schizophrenia in researches based upon simple diagnostic classifications.

Whatever the theoretical basis for this kind of treatment, its action was undoubtedly impressive and its results aroused interest in other methods of convulsion therapy. Bertolani in 1938 produced epileptiform seizures using ammonium chloride. Coramine was also used but, in general, the chemical methods of producing convulsions were felt to be unsatisfactory in that they involved a delay between/

between injection and the onset of the convulsion during which patients demonstrated objective signs of fear and distress.

During this time work on the electrical production of convulsions had been carried out on animals. Von Fritsch and Hitzig in 1870 in their monograph "The Electrical Stimulation of the Cerebrum" had demonstrated the electrical excitability of the brain and in particular that epileptic seizures could be produced in dogs by electrical stimulation of the exposed brain. Leduc (1902) found that certain animals when stimulated by electricity would fall asleep. Her experiments in "electrical sleep" were re-investigated by Rabinovitch (1906) who found that electrical stimulation of the dog's brain produced epileptiform convulsions. Weiss confirmed Rabinovitch's observation in 1905. In 1922 von Schilf induced epileptic fits in dogs electrically, without opening the skull, by placing electrodes under the conjunctivae and using an alternating current lasting for 0.5 seconds. As a measure of the time of application he used a contact pendulum which momentarily connected the source of the current with the subject. The convulsive threshold was determined by gradually increasing the stimulus current by means of a variable resistance in series. As a conclusion to his paper von Schilf suggested the possibility of/

of producing convulsions in man by a similar method (Patzold, 1940). Chiauzzi (1934) repeated work which had been carried out by Viale five years previously on the induction of convulsions in animals using a 50 c.p.s. alternating current at 220 volts and with a stimulus time of 0.25 seconds applied. This technique used electrodes placed in mouth and rectum and Chiauzzi confirmed that no obvious ill-effects were produced in the animals by such procedures. Spiegel in 1937 (see Jessner and Ryan, 1942) repeated von Schilf's experiment determining the convulsive threshold of animals by inserting electrodes under the conjunctivae. He noted that in this position there was less variation in the animals' electrical resistance than if the electrodes were placed in other positions. In May 1937 Bini read a paper entitled "Experimental research on epileptic attacks induced by the electric current" at the meeting of the Swiss Psychiatric Association in Berne. In this paper he reported results of his experiments on animals and suggested that further research might produce a similar method for use in man as a therapeutic alternative to cardiazol.

In the following year Cerletti and Bini (1938) described their apparatus and technique for the electrical induction of convulsions in humans as a therapeutic procedure.

Experience/

Experience with dogs had shown that they could administer almost any reasonable voltage with safety if they controlled the time of the stimulus within rigid limits. They felt, therefore, that electric stimulation was a potential therapeutic weapon in man if a technique could be worked out. Cerletti was turning over in his mind this problem when a friend informed him that "at the Rome slaughterhouse pigs are killed by electricity". He decided to see this operation for himself. There he was told that electricity had been used in the butchering of pigs for years, but he discovered that the animals were not killed in this manner, they were convulsed by an electrical current applied to their heads, then as the convulsion subsided their throats were cut and they were bled.*

Cerletti now set to work to discover exactly what was necessary to kill the pigs by means of an electric current, in other words, the minimal voltage and time invariably lethal. He experimented with different voltages applied over varying lengths of time; and by various electrode placements. He found that currents passed through the head were/

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*Footnote. Meduna (1958) relates amusingly how in fact the circle has recently been completed when a Danish slaughterhouse wrote to him to ask whether his most recently devised therapy, carbon dioxide inhalation technique, would be of value in the humane killing of pigs!

were tolerated better than those passed across the chest, for then long periods of apnoea and sometimes death ensued. He repeated his "treatment" of pigs until he felt confident that a convulsing current of electricity could be passed through the heads of humans without fear of permanent damage. He knew that the appropriate voltage was in the neighbourhood of 100 to 125 volts and that the safe time of application was about 0.3 seconds.

So he decided to apply such a current to the head of a human. Cerletti's own vivid description of the subsequent procedures is given in translation by Adamson (1955).

"These clear proofs, certain and oft repeated, caused all my doubts to vanish, and without more ado I gave instructions in the clinic to undertake next day, the experiment upon man.

'A schizophrenic of about 40, whose condition was organically sound, was chosen for the first test. He expressed himself exclusively in an incomprehensible gibberish made up of odd neologisms, and, since his arrival from Milan by train without a ticket, not a thing had been ascertainable about his identity.

Preparations for the experiment were carried out in an atmosphere of fearful silence bordering on disapproval in the presence of various assistants belonging to the clinic and/

and some outside doctors.

As was our custom with dogs, Bini and I fixed the two electrodes, well wetted in salt solution, by an elastic band to the patient's temples. As a precaution, for our first test, we used a reduced tension (70 volts) with a duration of 0.2 seconds. Upon closing the circuit, there was a sudden jump of the patient on his bed with a very short tensing of all his muscles; then he immediately collapsed onto the bed without loss of consciousness. The patient presently started to sing at the top of his voice, then fell silent. It was evident from our long experience with dogs that the voltage had been held too low.

I, bearing in mind the observations with repeated applications of the day before upon pigs, made arrangements for a repetition of the test.

Someone got nervous and suggested whisperingly that the subject be allowed to rest; others advised a new application to be put off to the morrow. Our patient sat quietly in bed, looking about him. Then of a sudden, hearing the low-toned conversation around him, he exclaimed - no longer in his incomprehensible jargon, but in so many clear works and in a solemn tone - "Not a second. Deadly!"

The situation was such, weighted as it was with responsibility/

responsibility, that this warning, explicit and unequivocal, shook the persons present to the extent that some began to insist upon suspension of the proceedings. Anxiety lest something that amounted to superstition should interfere with my decision urged me on to action. I had the electrodes reapplied, and a 110 volt discharge was sent through for 0.5 seconds. The immediate, very brief cramping of all the muscles was again seen; after a slight pause, the most typical epileptic fit began to take place. True it is that all had their hearts in their mouths and were truly oppressed during the tonic phase with apnoea, ashy paleness, and cadaverous facial cyanosis - an apnoea which, if it be awe-inspiring in a spontaneous epileptic fit, now seemed painfully never-ending - until at the first deep, stertorous inhalation, and first clonic shudders, the blood ran more freely in the bystanders' veins as well; and, lastly, to the immense relief of all concerned, was witnessed a characteristic, gradual awakening "by steps". The patient sat up of his own accord, looked about him calmly with a vague smile, as though asking what was expected of him. I asked him: "What has been happening to you?" He answered, with no more gibberish: "I don't know, perhaps I have been asleep."'

That is how the first epileptic fit experimentally induced in man through the electric stimulus took place.

So/

So electroshock was born; for such was the name I forthwith gave it."

While convulsive therapy was quickly recognised and accepted in Germany and Switzerland, it was not until 1938 that interest was aroused in Britain. W.R. Thomas and I.G. Wilson, after a tour of the continental clinics, presented an official report published by the Board of Control recommending cardiazol as a form of treatment. By this time the disadvantages of pharmacologically induced convulsions were being overcome by the use of electrical stimulation and E.C.T. was being applied in Britain and reported on in 1939.

Scottish mental hospitals were among the first to use these new forms of treatment in Britain. The outbreak of war obscured the trend of large-scale evidence for the efficacy of such physical therapies. If the figures for admission to Scottish mental hospitals are examined from 1900 to the present they show a striking rise in numbers commencing just prior to the last war and continuing into the immediate post-war period. This increase seems to be largely due to the increased numbers of voluntary patients seeking treatment in mental hospitals, reflecting not so much an absolute increase in the numbers of the mentally ill as an increased demand for treatment. This increase follows the introduction of/

of physical treatments but also coincides in Scotland with expansions in administrative and hospital services (Rodger, 1957). It is perhaps correct to say that the physical treatments contributed to this expansion and have tended to revolutionise ideas of mental hospital care and treatment, replacing the previous policy of custodial care by that of active treatment.

This change of attitude was as important for the psychiatrist as for the patient, since it introduced a significant change in his function and role and consequently in his professional status as a physician.

The convulsion therapy approach was not immediately accepted. Punch in 1938 commented: "An Italian doctor claims to cure depression by giving epilepsy. Any takers?". Hinsie in his "Visual Outline of Psychiatry" in 1941 still cast doubt on its efficacy. He says: "No system of ideas, delusions or hallucinations, obsessions or any train of normal thoughts can be caused to disappear through accidents, injuries or artificial means." E.C.T., however, was most readily accepted by doctors in mental hospitals who "faced with wards of humans seemingly doomed to incessant inner turmoil, to regression down to the level of a dumb animal or even to the vegetative stratum, mute, motionless, filthy and slowly deteriorating, or belligerent or self-destructive.... clutched/

clutched at any straw of salvation", (Gordon, 1948). The results which were obtained by the use of convulsant procedures were all the more dramatic when viewed against the historical background that physicians up till the 1930's were virtually as powerless to help a major human affliction as Hippocrates had been over 2,000 years previously. Even the slightest remission or transient improvement was held to be sufficient to justify the use of these new treatments.

Protagonists of the psychoanalytic approach felt that such physical methods were non-rational and even inhumane. Overholser (1949) asserts that the only consistent motivation for using physical methods was the physician's need to express aggression towards the patient. He deplored this attitude and stressed that physical methods represented a regression and arose mainly because of the excessive length and cost of psychoanalysis. This might be regarded as a rather parochial view since the physical methods of treatment have developed quite independently and not as substitutes for, or alternatives to psychoanalysis. Part of the concern with the propriety of the treatment arose from attitudes to epilepsy. It was felt that the deliberate induction of a "disease" such as epilepsy must be fraught with danger to the patient as the epileptic attack was indicative of brain damage. Experience with convulsant therapy and more recent/

recent work in neurophysiology has shown that the convulsion is a normal reaction to excessive stimulation and is not in itself pathological.

However, not all psychoanalysts maintained a categorical objection to E.C.T. Wayne (1955) suggests that the characteristics of the E.C.T. situation may awaken in the physician an attitude of omnipotence, a need to cure hostile impulses quickly and unresolved peeping tendencies. On the other hand antagonism towards E.C.T. may be motivated by the physician's fear of his own sexual and aggressive impulses!

Apparatus

Electroshock was one of several ways in which therapeutic convulsions could be induced. While it was recognised that the convulsion and not the method of its production was the significant feature of treatment, the electrical method possessed certain advantages among which were the relative simplicity of the apparatus itself, both in construction and operation. Cerletti and Bini's apparatus involved a source of alternating current, a mechanical time switch, an adjustable voltage output of between 80 and 140 volts, and a circuit for measuring the resistance of the skull. This latter circuit consisted of a small variable D.C./

D.C. voltage of 2 volts maximum, allowing a current of 1 milliampere through the patient to give a reading on a meter. On the basis of this measured resistance they calculated the voltage required to pass 300 to 600 milliamperes A.C. through the patient, assuming that this measure was independent of frequency and consequently that Ohm's law applied. They found that convulsions were produced by currents of 200 to 600 milliamperes flowing for 0.1 to 0.2 seconds. The electrodes were made of thin wire gauze fastened to a metal crossbar built into the headband and pressed close to the upper part of the temples. Between the wire gauze and the crossbar a rubber cushion was inserted to ensure a uniform close fitting. To reduce surface resistance the temples were shaved, the skin was scrubbed and moistened with saline.

In the following year apparatus similar to that of Cerletti and Bini had been devised, built, and its use reported in Britain and America (Fleming, Golla and Walter, 1939; Kalinowsky, 1939; Shepley and McGregor, 1939). Strauss and Macphail (1940) were the first in this country to introduce a portable electrical convulsive apparatus and to recommend this treatment under outpatient conditions. They included an alternating current circuit for measuring the patient's resistance, using a resistance bridge excited by a low voltage/

voltage transformer, because their experiments had shown the inaccuracies of the previous methods using direct current measures; for example, the D.C. resistance of a patient measured by an ohmmeter was 370 ohms and by a D.C. Wheatstone bridge was 1,650 ohms; using an A.C. bridge with a small current of less than 200 microamps the resistance obtained was only 0.12 ohms.

Most machines have maintained the same general principle as Bini's original device, even for a long time incorporating the D.C. measurement of resistance although in fact this had little relevance to the resistance which would be set up when the A.C. stimulus was applied to the patient.

Later modifications of the machine have been concerned to generate wave forms independent of the domestic 50 cycles A.C. mains supply. Many wave forms have been introduced, varying in shape, in frequency of repetition and in the total duration of the stimulation applied, and attempts have been made to relate variations in the stimulation applied to variations in the physiological and clinical response. Such technical details are discussed by Liberson (1953).

CLINICAL/

CLINICAL USES OF E.C.T.

Although initially devised as a treatment of schizophrenia, E.C.T. has been used in many psychiatric conditions. Currently the treatment has come to be used almost exclusively in the affective illnesses and most text-books indicate E.C.T. as the treatment of choice in depressive conditions.

The following is a short review of some typical results reported with E.C.T. in various psychiatric disorders.

Schizophrenia. The therapeutic use of convulsions was originally directed towards treatment of schizophrenic illnesses. Insulin hypoglycaemia is, however, nowadays more often applied in schizophrenia as this illness tends to prove unresponsive to E.C.T. alone, although Lopez Ibor at the International Congress in Paris (1950) considered that E.C.T. was an effective treatment of schizophrenia if a long series of convulsions was applied. He considered that at least 30 convulsions were necessary to obtain good remission rates in schizophrenia. Of the schizophrenic group of illnesses, catatonic excitement is considered to be the most favourable group for treatment with E.C.T. In this particular illness in which the patient is often debilitated due to a high degree of activity without adequate intake of food and water, it is often necessary to use E.C.T. as an emergency/

emergency means of management of the patient and by using intensive convulsion treatments the physical and mental symptoms may be improved after two or three days of treatment. In other types of schizophrenia it is felt that the response to E.C.T. is not so favourable and clinicians have preferred to use insulin treatment rather than electrical. It is also possible in the treatment of schizophrenia to use combined E.C.T. and insulin (Mayer-Gross, Slater and Roth, 1954). Hemphill (1942) recommended that E.C.T. should be tried in all cases of schizophrenia before insulin therapy was instituted. Other workers have suggested that intensive E.C.T. to the point of confusion can be useful in schizophrenic conditions but on the whole there are conflicting reports as to the efficacy of E.C.T. in schizophrenia and few reliable figures are available because many of the studies do not specify the nature or duration of illness (Cook, 1944).

Psychoneurosis. E.C.T. appears to have few indications in the treatment of the psychoneuroses. Kalinowsky (1953) deplores the indiscriminate use of E.C.T. in such conditions and points out that psychoneurotic reactions can be aggravated by the ill-advised use of E.C.T. Often the side effects of muscular pain or headache are added to the patient's conversion symptoms and the temporary confusion may increase the/

the patient's anxiety. The memory disorder too, which is reported in E.C.T., is often considered to be worse in psychoneurotic cases. Generally, although some workers have reported success with E.C.T. in psychoneurotic conditions (e.g. Hemphill and Stuart, 1949), it is accepted that only in psychoneurotic conditions in which depression is present does E.C.T. have any indication.

Psychosis due to organic brain disease. Although E.C.T. was intended for use in the functional psychoses, some workers have suggested that convulsive treatment is of value in treating the psychotic manifestations of brain disease such as excitement in acute organic reactions. E.C.T. may be used as an adjunctive therapy while specific treatment is being undertaken and in this way the patient may become more co-operative or tractable. The symptomatic depression which develops during treatment by ACTH or cortisone has been claimed to be treated successfully by E.C.T.

Of all the organic conditions, the use of E.C.T. in epilepsy seems to be the most interesting. Early on it was considered that E.C.T. itself might be a specific treatment for epilepsy as the convulsive threshold could be raised by E.C.T. to a level at which spontaneous fits could be prevented. Caplan (1945) reported success in using E.C.T. as an accessory

to/

to routine pharmacological methods. He showed that, when convulsions persist in spite of full doses of anti-convulsive drugs, convulsive treatment may be of value even for institutional epileptics. The rationale was that E.C.T. would replace the spontaneous epileptic fits occurring at inconvenient times or in dangerous circumstances by convulsions electrically induced under controlled conditions of time and place. In 24 cases treated on this basis half showed a reduction in the incidence of fits to less than one quarter of their former number. In 16 cases with an associated psychosis the symptoms were ameliorated in nine patients. Irritability and aggressiveness were found to be particularly amenable to treatment by E.C.T. However, the effects of the treatment both on the fits and psychotic symptoms was transient.

Apart from the convulsion itself there have been successful applications of E.C.T. in cases of epilepsy where psychic equivalents were an important feature of the illness. Such equivalents as automatism, irritability, clouding of consciousness, etc. are generally regarded as heralding the onset of a grand mal convulsion. It is felt that if this grand mal is produced artificially such equivalents can be avoided and the epileptic twilight state can be reduced in its duration.

Other/

Other conditions. In patients suffering from psychopathic personality, sexual deviation and even mental deficiency, E.C.T. has been used and occasional success is reported. These reports are usually of a single case and success may be claimed on the basis of the removal of the accompanying affective disturbance such as depression. E.C.T. has also been advocated as a treatment in the removal of intractable pain and even at one time as a treatment of rheumatoid arthritis on the basis that the natural liberation of ACTH which occurs with E.C.T. would be as effective a treatment of the arthritis as massive doses introduced into the body.

Affective disorders. Bennett (1938) was the first to report successes in the treatment of depressive psychosis by pharmacological convulsions. In the same year other workers confirmed his successes (Low et al., 1938; Cook and Ogden, 1938). Muller (1938) listed the reports from various workers and records an over-all recovery rate of 58% with a further 13% improvement in a total group of 148 patients. Bennett (1941) having treated 146 patients suffering from affective disorders by means of convulsion therapy, reported 53% complete recovery and 44% social remissions. In 1942 Furst and Stouffer reported that of 65 patients treated by E.C.T. for affective disorders, 73% were able to leave hospital/

hospital after an average of only 45 days and another 11% were improved. Impastato and Almansi noted that the remission rate of 80%, which they obtained in a group of patients suffering from affective psychosis and treated by E.C.T., was exactly the same as for metrazol-induced convulsions (Caplan, 1945). Fitzgerald (1943) reported 78% recovered and 17% improved after treating 150 cases of depression by E.C.T. Batt (1943) described 100 depressive psychoses treated with electrically induced convulsions in whom improvement was obtained in 87 cases.

These early reports showed encouraging results with E.C.T. in cases of depressive psychosis. When duration of illness was investigated in relation to prognosis it seemed that, contrary to the findings for schizophrenia where the length of the illness was a significant factor, in the depressive psychoses even chronic cases can respond to convulsive therapy. Fitzgerald (1943) classified his cases according to duration of illness and found recovery rates to be 76% out of 89 under one year, 13 out of 17 between one and two years and nine out of 20 over three years' duration. He concluded that, except in cases of more than three years' duration of illness, the results of treatment are not affected.

The fact that good results arise early in the use of any treatment is recognised. It is cynically observed that in many/

many of the physical therapies a recovery rate of the order of 2/3 of the treated group can be obtained with almost any new substance. More constructively one can claim that such factors as suggestibility, the patient's and doctor's enthusiasm for the treatment, changes in the amount of attention paid to the patient and environmental changes can produce quite striking results which, however, are not necessarily due to the exhibition of any particular treatment. However, at about this time a survey was undertaken by Penrose and Marr (1943) which, in its design, was able to eliminate the ad hoc nature of the conventional clinical trial. Using actuarial methods they evaluated the results of shock therapy by estimating the chances of recovery of patients remaining in hospital without such treatment. From a study of the hospital records of Ontario Mental Hospitals they found that during 1941 and 1942 56% less patients on the average suffered from affective psychosis than would have been the case if no E.C.T. had been given.

In 1950, when most clinicians were being impressed by the success of E.C.T., Karagulla (1950) published the results of an investigation of the effectiveness of E.C.T. in depressive states compared to conservative treatment. Using two groups of patients treated at the Royal Edinburgh Hospital for Mental and Nervous Disorders in the years 1900-1939 as controls/

controls, she compared four groups of patients treated by E.C.T. in the years 1940-1948. As a result of her study of the comparative results obtained from the six groups she concluded that "the percentage rate of recovery does not vary greatly whether patients are treated conservatively or with electric convulsion therapy; such slight differences as may exist are statistically insignificant", and also "the use of E.C.T. did not shorten the duration of hospitalisation to any significant degree".

These conclusions were surprising to clinicians, particularly because the paper quoted authoritative support for her arguments and statistical reasoning. However, Slater (1951) re-examined her report and drew attention to the fact that the differential improvement rate in favour of the 1900-1939 group could be attributed to the greater period of time in which such improvement could occur in contrast to the eight year period in the E.C.T. group. More important was his observation that Karagulla had in fact obscured a higher recovery rate and lower death rate by a statistical device. Arguing that "death unless in the form of suicide cannot be attributed to the depressive process" she had recalculated the percentage of recovery, improved and not improved after all deaths were omitted. Slater maintained that death was a risk attaching to leaving depressive patients untreated/

untreated by E.C.T. Reappraising the figures with death rates included showed a higher proportion of recoveries in the treated group. Again Karagulla's claim that length of hospitalisation was not reduced in E.C.T. cases was shown to rest on a comparison with a control untreated group during the same period. Her figures showed that a considerable period of time elapsed between admission and the beginning of treatment. Any patient admitted to hospital during 1940-1948 and who recovered rapidly would be counted in the control group. The treated group thus had an ab initio selection in favour of cases with long duration. The effects of this selection are to bias the study in favour of the prognostically less favourable group and to add to the period of hospitalisation the period of non-recovery. Slater's arguments reverse Karagulla's propositions and make her work a strong confirmation of the effectiveness of E.C.T. in depressive states.

Even with the newer euphoriant and tranquillising agents E.C.T. is still considered the treatment of choice for depressive illnesses and a response is generally observed after a course of five to eight treatments. Most of the range of depressive illnesses is capable of response to E.C.T. although there are types of illness in which accompanying complications/

complications may reduce the expected high recovery rate - for example, depressions complicated by arteriosclerosis or by senile cerebral changes. However, Roth and Morrissey (1952) have argued that very often the diagnosis of a senile deteriorative illness can be offered on inadequate clinical grounds and that a careful examination of the senile patient can show the illness to be depressive in nature, and thus amenable to treatment by E.C.T.

In general, in the manic episodes of affective illnesses treatment by E.C.T. is felt to be best undertaken on an intensive basis, i.e. several treatments daily for a period of three or four days until the manic episode shows response. In recurrent depressions or recurrent manias the treatment does not prevent future recurrences. However, since E.C.T. reduces the length of the depressive or manic episode its therapeutic efficiency can be judged in terms of the length of hospitalisation necessary for the episode of the illness or in the prevention of suicide.

One further justification has to be offered, viz. that, when it is possible to give E.C.T. on an out-patient basis, it is often feasible to allow a patient suffering from an affective disorder to remain both at home and at work while still being treated for a disorder which might otherwise have led to his hospitalisation for a long period. The recurrent manic/

manic or depressive patient can be induced to follow a regime whereby he reports to hospital to undertake a prophylactic course of treatment by E.C.T. as soon as he becomes aware of the earliest symptoms of his recurring illness. This is illustrated in the following case.

Case History. A 60 year old retired Air Force officer was certified at the request of his family, acting on the advice of the family lawyer, because he had become involved in an immense financial commitment which he was unable to meet and because his judgement in business was considered to be faulty. He was diagnosed as suffering from a manic attack. On admission he was a tall, wiry, hyperactive man, constantly explaining a series of speculative ventures which he "had just thought up". One such scheme involved turning the whole hospital into a private sanatorium - "You chaps ought to stress sana- not insanatorium...extend on a business footing and your salary's trebled". Because of his liability to fatigue and impatient disregard for food he was heavily sedated and a course of E.C.T. was begun. After six treatments he was tractable and objectively calm, and he was able to consult with his business associates to solve his financial difficulties.

The history of the illness showed that over the previous ten years he had suffered from a cyclical series of manic episodes occurring on the average annually and lasting for about/

about six weeks. Although his basic hypomanic personality was an asset in business, the acute manic episodes had previously led to difficulties as on the occasion of his admission. From his account of the illness he recognised that such manic attacks were heralded by sudden changes in sleeping habits and he agreed to return to hospital for a course of E.C.T. when he noticed these changes. For the subsequent four years he successfully maintained this regime.

The Use of "Relaxant" Drugs

The successful use of E.C.T. in depressive illnesses was dependent upon the physical suitability of patients to undergo this convulsive treatment. Although the contra-indications discussed by Kalinowsky and Hoch (1952) are far fewer than an a priori judgement would have predicted, it was felt that tolerance of the treatment would be improved in patients with cardiac disease or skeletal damage if the convulsive movements during treatment could be reduced or inhibited. Benner (1940) used curare as a "relaxant" drug in order to prevent possible complications. Since that time a number of shorter-acting "curare-like" substances have been used (see Evans, 1954) alone or in combination with an anaesthetic in the procedure referred to as "modified E.C.T."

Montagu (1953) discussed such modified procedures and pointed/

pointed out that as the possibility of complications could not be predicted it would be justifiable always to use the modified method as a routine. Kalinowsky (1952) and Maclay (1953) suggested that the relaxant technique should only be used with caution as the relaxants in their turn are potentially liable to complications. However, such complications can be prevented by the employment of a skilled anaesthetist during E.C.T. and the modified form of the treatment has now become a routine measure. In fact the finding at a recent medico-legal appeal (Lancet, February 1957) was to the effect that a failure to use relaxants might nowadays be considered to be professional negligence.

The observations reported in this thesis were, however, all carried out on patients being given the unmodified form of the treatment and in several instances patients undergoing the modified treatment were deliberately not selected. This means that by present day standards the material is atypical, for at the beginning of these investigations the practice was to use modified treatment only in special cases. In subsequent investigations, in the interests of homogeneity, this criterion of observing only "raw" E.C.T. was maintained. Apart from keeping the sample studied homogeneous it allowed the effects of the E.C.T. itself to be reflected without

secondary/

secondary effects from anaesthetics yielding significant psychological changes, or reducing the patient's accessibility.

While not directly relevant, it is of interest to note that no really authoritative statement has been made of whether in fact the modifications of the treatment have any effect on the results of the treatment. There have been several impressionistic statements to the effect that, while the modified treatment yields results comparable to the unmodified, the former has advantages in reducing the patient's fear or apprehension. Ardis and Wyllie (1953) in their study found a small group of patients who apparently did not give a response to modified E.C.T. such as would have been expected from "straight" E.C.T.

Seager (1958) carried out a comparison of the results of unmodified and modified E.C.T. by a follow-up at one year, 18 months and two years after treatment. He reports that "these figures show a tendency for patients who receive modified treatment to make a less satisfactory recovery after a longer stay in hospital". His experiment is not crucial, however but his findings warrant further investigation using matched groups of patients. His results justify the precaution taken in this study of investigating only homogeneous groups with respect to method of treatment.

CONCLUSION/

CONCLUSION

As a readymade conclusion to this section the following quotation can be used. It represents information given to patients and relatives when the treatment consent form is presented for signature. Such information is usually presented verbally but in the Washington area it was decided to prepare a written information sheet to give to the patient and relatives for reference. The text is quoted from correspondence of Drs. Rodis and Groh which appeared in the A.M.A. Archives of Neurology and Psychiatry for July 1956.

"Electroshock therapy is an accepted form of treatment for certain types of nervous and mental illness. It has been used successfully in thousands of cases since its introduction in 1938. It is one of the most effective ways of treating depressed patients with suicidal tendencies or patients who might otherwise require prolonged hospitalization.

The psychiatrist himself gives the treatment, using a specially designed electronic instrument. The treatment consists of passing a controlled electric current between two electrodes applied to the patient's temples. In some instances, the patient may be given medication prior to treatment to reduce tension and produce muscular relaxation.

The/

The patient experiences no discomfort or pain during the treatment; he does not feel the electric current and has no memory of the treatment. When the treatment is given, the patient becomes immediately unconscious and has strong muscular contractions of a convulsive nature. These contractions last 35 to 50 seconds. Complete relaxation follows and several minutes later the patient gradually regains consciousness. His condition is similar to that of a patient emerging from brief anaesthesia. Within 15 to 60 minutes, the confusion clears and the patient is able to recognize his surroundings. Following this, the patient is permitted to get up and about. Headache and nausea sometimes occur, but these are infrequent and usually respond rapidly to simple treatment.

The number of treatments in any given case will vary with the condition being treated, and the individual response to treatment. The frequency of treatment will also vary with each case. As the treatments progress (usually after the 3rd and 4th treatment) a certain amount of haziness of memory and confusion develops. This memory impairment is transitory and clears up within several weeks following/

following the last treatment.

Electroshock therapy, like any other medical or surgical procedure involves a certain amount of calculated risk. Complications are infrequent, the most common being fractures and/or dislocations of the extremities, or fractures of the vertebrae. These may sometimes occur, in spite of all precautions and must be looked upon as a recognized hazard of the treatment. Should such an injury occur, the patient and his family will be notified and urged to call in a physician competent to treat the complication.

During the hospital treatment, the patient's general care is provided by the hospital personnel. On discharge from the hospital, the patient begins a "convalescent period" of several weeks' duration during which he must be under strict supervision of some member of the family or some responsible person selected by the family. This precaution is necessary because of the temporary mental confusion and impairment of memory. During this entire period, the patient is not permitted to drive an automobile, to transact any business or to carry on his usual employment until the doctor gives his permission.

He/

He should not be permitted to leave the house unless accompanied by a responsible companion because of the possibility that he may wander off and get lost. Supervision is very important and must be provided by a responsible person.

Finally, a word about the results of treatment. Although the results in most cases are gratifying, not all cases will respond equally well. As in all forms of medical treatment in general, some patients will recover promptly; others will recover only to relapse again and require further treatment; still others may fail to respond at all.

The above information has been prepared to answer some of the most frequently asked questions concerning electroshock therapy. The treating psychiatrist will be glad to answer any further questions which may occur to the patient or his family.

When the patient is treated by the ambulatory or outpatient method the family, or someone designated by the family, has definite and real responsibility for the patient's care. The patient is escorted to the hospital or the doctor's office. The responsible person stays with the patient until he reacts from the/

the treatment and then escorts him back home. During the approximately two-week period of treatment and for at least two or three weeks following termination of treatment the patient must be under the strict supervision and companionship of the family."

S E C T I O N II

Reports and Discussions of Investigations

INVESTIGATION I.	A follow-up study of the effects of treatment.
INVESTIGATION II.	Fear of treatment.
INVESTIGATION III.	Behaviour during convulsions.
INVESTIGATION IV.	Recovery of consciousness in E.C.T.
INVESTIGATION V.	The effect of E.C.T. on perception of flicker.
INVESTIGATION VI.	Cognitive changes during E.C.T.

Investigations II to VI form a unity in that they reflect the time sequence of events in the treatment situation. A representative aspect of each phase of the treatment is studied and the findings are discussed in the light of their psychophysiological implications.

THE EFFECTS OF TREATMENT

Investigation I

A follow-up study of all patients who had E.C.T. as outpatients at the Manchester Royal Infirmary during the previous three and a half years was carried out in December 1952. This period was chosen because after this date relaxant drugs were used routinely in the application of E.C.T. Patients covered in this follow-up were selected as having been treated without relaxant drugs, special cases in which relaxant drugs had been exhibited having been excluded. The follow-up was done by post on patients whose names appeared in the E.C.T. record books. Patients were sent a reply paid letter which told them that the hospital was interested in how they had fared after receiving electric treatment and asked them to indicate whether in their opinion they had fully recovered, had improved to some extent, were no better or were worse after having this treatment.

The original form of the questionnaire had included specific questions on side effects of treatment but it was felt that these items had been acting as clues to what the patient felt should be the expected answers. The final form of the letter, therefore, included only an open question asking/

asking patients to express any comments about the treatment which they cared to make, in order to try and get a more spontaneous indication of any side effects. On the whole it was felt that it was better to miss reports of these side effects rather than to have such effects exaggerated in the study by suggesting them. Over 500 returned forms were finally available, representing almost 50% of the letters originally sent out.

From the casenotes the number of treatments recommended and the actual number of treatments given were obtained. Although the number of treatments recommended was not always recorded, the approved course in the clinic was to recommend a dosage of six E.C.T. in the first instance with a routine reappraisal of the case after the sixth treatment. The numbers of treatment actually given when analysed suggested that the likelihood of discontinuing treatment was greatest up to the third treatment of the course, and as three treatments was not considered clinically to be an adequate number to determine improvement with E.C.T., all cases who had not had at least four treatments were excluded. The 477 cases which remained after this selection showed a distribution of the number of treatments

as/

as follows:-

No. of E.C.T.	Frequency
4	19
5	24
6	46
7	59
8	239
9	40
10	39
11	10
12	1
	n = 477

The modal number of treatments in this group is, therefore, the most usually prescribed number, viz. eight. It should, of course, be noted that within this three-and-a-half year period some of the patients did in fact have more than one course of E.C.T. The figures above refer to one course only.

Results

Of the total group examined 394 considered themselves to have improved and 83 reported no improvement. This yields an overall improvement rate of 82.6% which is high for such a mixed diagnostic group. Part of the reason for the elevated improvement rate is, of course, the fact that the follow-up was conducted on patients who had been for some long time out of hospital care. Many of these patients were/

were suffering from illnesses which by their nature were self-limiting. Thus the effect of the treatment is only partly reflected in the results of such a follow-up.

Of the 477 patients 212 were male and 265 were female. The average age for the group was 40.1 years with no significant sex difference (males 39.2, females 40.3). When the improvement rate is calculated by sex it shows 75.3% for males and 83.24% for females, the difference by X^2 being marginally significant at the P = 0.06 level. (See Appendix A. These calculations were carried out on a smaller group of 359 patients, 162 male and 197 female because of the inadequacies and discrepancies in case records. It was only in this latter group that age and diagnosis could only be confirmed in the records. The proportion of male to female in this smaller group is, however, not significantly different from that of the larger group.)

Breakdown by diagnosis

This group represents a heterogeneous diagnostic sample. During the period studied the referral of cases for E.C.T. had been the responsibility of several physicians each of whom apparently selected patients on different grounds. Thus the group includes a wider range of diagnosis than the expected affective disorders.

Diagnoses/

Diagnoses were reduced to the following classification:-

Affective Disorders n = 217	Depression Melancholia Endogenous depression Recurrent depression Agitated melancholia	Psychotic Depression n = 277
Depression of epochs n = 60	Senile depression Involutional melancholia Menopausal depression Puerperal depression	
Depression and Psychoneurosis n = 31	Reactive depression Depression with psychoneurosis Psychoneurotic depression	Neurotic Depression n = 31
Psychoneurosis n = 44	Effort syndrome Anxiety reaction Hysteria Phobic reaction Neurasthenia Obsessional disorder Neurotic character Post-traumatic neurosis	Psycho-neurosis n = 44
Miscellaneous	Schizophrenia Paraphrenia Alcoholic hallucinosis Impotence Cyclothymic personality	

The main distinction lies between psychotic depressive reactions and the psychoneurotic reactions. Within the former group an attempt was made to single out special instances of affective disorders such as senile, involutional, menopausal or puerperal forms of the illness. For want of a better term these were headed "Depression of epochs".

Improvement/

Improvement rates by diagnosis and sex

Affective disorders	$\frac{181}{217}$ = 83.4%	Male	$\frac{87}{105}$ = 82.8%
		Female	$\frac{94}{112}$ = 83.9%
Depression of epochs	$\frac{51}{60}$ = 80.5%	Male	$\frac{12}{16}$ = 75%
		Female	$\frac{39}{44}$ = 88.6%
Depression with psychoneurosis	$\frac{20}{31}$ = 64.5%	Male	$\frac{8}{17}$ = 47.1%
		Female	$\frac{12}{14}$ = 85.7%
Psychoneurosis	$\frac{28}{44}$ = 63.6%	Male	$\frac{12}{20}$ = 60%
		Female	$\frac{16}{24}$ = 66.6%

It will be noted that the sex difference noted in the improvement rates for the whole group seems to be derived from the higher recovery rates for female patients in the categories "depression of epochs" and "depression with psychoneurosis".

When inter-group comparisons are made it will be seen from Table I (derived from appendix A) that there is no significant difference between the "affective disorder" group/

TABLE I

FOLLOW-UP INVESTIGATION

Probability Values - Relationship between Diagnostic Categories

	Affective Disorders	Depression of epochs	Depression with psycho-neurosis	Psycho-neurosis
Affective Disorder	-	0.75	0.01	0.006
Depression of epochs	0.75	-	0.02	0.008
Depression with psycho-neurosis	0.01	0.02	-	0.95
Psychoneurosis	0.006	0.008	0.95	-

group and the "depression of epochs" group and none between the "depression with psychoneurosis" group and the "psychoneurosis" group. The other differences are seen to be significant. This finding confirms the specific nature of the response to E.C.T. in diagnostic categories and confirms the points made about the clinical use of the treatment discussed in Section I.

Apart from this rating by the patients of the effectiveness of E.C.T. the responses to the open question asking for any comments about the treatment proved of interest. About a quarter of the returns showed some comments by the patients - some laudatory and some uncomplimentary. Apart from these general statements the two main items of interest were complaints of memory difficulties subsequent to the treatment and apprehension or fear of the treatment while it was being given.

Complaints of memory difficulty. Eighty patients (16.8%) spontaneously recorded difficulties in remembering after treatment. Only three of these cases, however, gave any indication that such difficulty had persisted beyond several weeks after the end of a course of treatment. Others reported that their difficulty had not persisted. One male patient wrote:

"Resuming full duties at my work the week following

termination/

termination of the electrical treatment, I found memory at first more noticeably disturbed; names of people, or alternatively faces, events in gaps, even the technical side of my work (horticulture), in which I have spent my full life, seemed strange, and effort to recall seemed very disturbing, making executive work somewhat difficult. Despite this I still felt progressive improvement and after two weeks I had two weeks' holiday.....from then on dispensing with the need of sleeping tablets and still steadily improving."

The significance of such changes in ability to remember will be discussed in a later section. For the moment it can be seen from Appendix A that the X^2 test of significance of the relationship between complaints of memory difficulty noted in this form and the degree of improvement claimed by the patients was not significant ($P = 0.5$). It would seem on this evidence that the complaint of memory difficulty occurs independently of clinical result.

Complaints of fear of treatment. Sixty-three patients (13.2% of the total group) indicated that they had experienced apprehension or fear of having E.C.T. Some used terms to indicate that they were terrified before each treatment, others that they were very worried about the treatment/

treatment but were unable to specify what this worry was. One female patient wrote: "It was not being afraid that you wouldn't wake up after the shocks. It was a worry about not waking up and not feeling properly. The thought of having gas at the dentist's never used to worry me before."

Of these 63 patients who indicated fear or apprehension retrospectively, only five of them however considered that they had not benefited from treatment by E.C.T. Comparing the proportion of assessed recovered among those retrospectively reporting fear of the treatment with those who did not report such fear it was found that the difference yielded by x^2 test was significant ($P = 0.05$, see Appendix A). The direction of significance is such that apparently a higher proportion of those patients who expressed fear of E.C.T. also felt themselves to be improved by it.

This was not an easy finding to accept, particularly when no obvious intermediate relationship was available and one was left to consider the direct relationship between fear of treatment and improvement. However, the method of the investigation, although direct and simple in administration, had the following faults:-

a) That the open question in the original letter allowed for randomness in the patient's replies. The amount of information returned is a function of the proportion of the total/

group choosing to report fear and not of the actual number who actually experienced fear. From the data there is no way of assessing the number of patients who may have experienced fear but did not report it.

b) That the time which had elapsed since the treatment varied considerably among the total group followed up. There is the possibility that less fear would be reported after some considerable time had elapsed since treatment.

d) The total number of patients reporting such fear (i.e. 63) is small enough to represent a subsample of the total group and the reported fear could occur predominantly within one diagnostic category either determined by the potential response to treatment (as in the affective disorder group) or in the group where general anxiety reactions might be expected to predominate (the psychoneurotic group). If this were so a comparison of the proportions of those recovered and reporting fear would show (a) no advantage compared to the proportions reporting recovery in the affective disorder group and (b) an increased significance when compared to the proportion reporting recovery in the psychoneurotic group.

This latter point was capable of being examined further as an hypothesis. If fear of treatment were related to nonspecific anxiety or fear-reactions independent of treatment/

treatment then in a psychoneurotic group the number of patients reporting such fear of treatment would be higher and would be independent of the response to treatment.

FEAR OF E.C.T.

Investigation II

It was possible to obtain an experimental group which would allow this hypothesis to be examined. At a weekly teaching clinic it was recognised that because of selection of patients as teaching material a high proportion of psychoneurotic reactions would be encountered. Out of this group a regular number of patients was referred for out-patient E.C.T. Observations were carried out on 50 such consecutive patients at a follow-up clinic one month after the completion of their course of outpatient treatment. Some degree of selection is involved in that only those patients who had attended for a minimum of four treatments were included. This was done, as previously, in order to reflect a degree of improvement which could be ascribed to E.C.T. This selection, however, operates against rather than exaggerates any positive finding as the procedure eliminates some patients who had stopped treatment before the prescribed course had been completed and fear-apprehension of the treatment is one of the most important reasons for stopping treatment.

During/

During the follow-up interview the patient's response to the treatment was assessed clinically, based on the reports of the patient and his relatives and on the absence of side effects. This assessment was recorded on a four-point scale:-

a) Much improved, referring to complete absence of symptoms with full return to work or to household duties.

b) Improved meant some reduction in symptoms but not necessarily involving complete return to work or to household duties. It was felt by the clinician, however, that no further treatment would be necessary.

c) Slight improvement referred to some reduction in symptoms but that further treatment might be necessary before improvement could be ensured.

d) No improvement covered those patients in whom no change in symptoms could be noted or whose condition was worsened.

During these interviews questions were directed generally at the patient's attitude to the treatment, trying to avoid any suggestions about fear or apprehension. The first question was "How did you feel about having the treatment?" If the patient indicated that he had experienced fear/

fear he was asked to describe the fear further. If his reply to the first question was noncommittal he was asked if he would recommend electrical treatment to another person who might need it. Any misgivings he might have here were followed up by asking for explanations. Finally, if the patient had not indicated any fear in his replies to these two questions he was asked "Was there anything about the treatment that worried you?" This latter question was used deliberately to confirm that fear had not been reported.

The presence of fear of the treatment was recorded on a four-point scale:-

0 = none expressed

+ = slight apprehensiveness

++ = marked apprehensiveness but not sufficient to interfere with the patient's co-operation in treatment.

+++ = very marked fear generally necessitating special reassurance during the course of the treatment or leading to abandonment after less than the prescribed course (but including at least four treatments).

In the group of 50 consecutive patients there were 34 females and 16 males, giving a much higher preponderance of females than in the group in investigation I. The average age of the group was 39.9 years (males 40.1, females 39.8). Although the average age for males was higher in this group than/

than for females it was not significantly so and none of these averages differed significantly from the average of the larger group previously investigated. The frequency distribution of ages was narrower in range than in the follow-up group but not significantly so (see Appendix B). The composition of the group by diagnosis as in investigation I was as follows:-

		Males	Females
Affective disorders (including depression of epochs)	13	4	9
Depression with psychoneurosis	14	2	12
Psychoneurosis	22	9	13
Miscellaneous	1	1	0
	50	16	34

This shows the preponderance in this group of psychoneuroses and depressions with psychoneuroses, differing from the group examined in investigation I where affective disorders predominated.

The ratings for degree of improvement and the amount of fear expressed are given in Table II. The improvement rate for the group (improved + much improved) is 64%, significantly lower than the overall rate for the group examined in investigation I and accords with the improvement rate found for the psychoneurotic subgroup in that investigation (i.e./

TABLE II

Relationship between fear of treatment and response to treatment

Rating of fear	Much Improved	Improved	Slightly Improved	Not Improved	Totals	%
+++	2	1	2	1	6	12%
++	4	4	1	2	11	22%
+	9	4	1	3	17	34%
0	5	3	2	6	16	32%
Totals	20	12	6	12	50	100%
%	40%	24%	12%	24%	100%	

(i.e. 63.6%).

Table II also shows that 68% of the group reported some degree of fear of treatment and 32% claimed to have experienced no fear. To test the hypothesis that this fear was independent of the response to treatment, two by two contingency tables were constructed (see Appendix B). The ratings of fear of treatment were capable of being split in two ways - one including all patients who had expressed any degree of fear and contrasting this group with those who were considered to have experienced no fear, and the other by grouping together those patients who had experienced marked apprehensiveness (++) and very marked fear (+++) and comparing this group with those patients who had reported only slight apprehension (+) or no fear at all (0). Testing for significant departures from independence by X^2 with Yates' correction for continuity showed that neither of these contingencies yielded significance (P= 0.16 and 0.70 respectively).

This finding suggests that in this predominantly psychoneurotic group fear of treatment is independent of response to E.C.T., i.e. the experience of fear is not associated either with a tendency to improve with E.C.T. as investigation I had suggested, or with a tendency to show no improvement, the contrary expectation. It is still possible that/

that the difference in the findings between the previous group and this present smaller group might be explained by an association with diagnostic categories and that in a group composed predominantly of affective disorders the original observation would still hold. If this were so, the overall improvement rate for this group would have been higher and the proportion of those in the affective disorder group reporting fear would be larger than in the psychoneurotic group.

Table III shows the relationship between the ratings of fear reported and diagnostic categories. In the affective disorder group eight out of 13 patients, and in the psychoneurotic group 14 out of 22 report some degree of fear or apprehension of treatment. These proportions do not differ significantly. It would thus appear that the hypothesis based on the assumption that fear of treatment is related to nonspecific anxiety associated with the diagnosis of psychoneurosis is not confirmed.

From Table III, however, it can be noted that in the group of patients diagnosed as suffering from depression with psychoneurosis, and who could be assumed to be a diagnostic mid-group between affective disorders and psychoneurosis, there appears to be a high proportion of the group who show fear of treatment, only two patients reporting

no/

TABLE III

Patients reporting fear of treatment and diagnosis

Rating of fear of treatment	***	**	*	0	
Affective Disorders	2	3	3	5	13
Depression with Psychoneurosis	1	4	7	2	14
Psychoneurosis	3	4	7	8	22
Miscellaneous	0	0	0	1	1
	6	11	17	16	

no fear. However, this proportion is not confirmed as being statistically significant from the other two main diagnostic groups (see Appendix B).

There appears to be no confirmation of the finding in investigation I of a relationship between fear of treatment and response to treatment. Further, it is not confirmed that such fear occurs more frequently in one diagnostic category than any other. Perhaps more important clinically is the assertion that fear of E.C.T. need not necessarily detract from the response to the treatment.

Discussion

It is interesting to note that in the 20 years in which experience of E.C.T. has accumulated, the significance of and even the presence of fear of the treatment has only been slowly recognised. In Section I it was pointed out that an important benefit in the development of E.C.T. by Cerletti and Bini was the absence of fear such as was noted in patients undergoing other forms of convulsion therapy. Fear in metrazol therapy, for example, was recognised and documented. Clark and Norbury (1941) described the "fleeting but quite definite and almost animal-like expression of fear that appears just before the first tonic convulsive tightening of the body". So significant did fear appear to these/

these authors that they suggested that the mechanism of recovery in metrazol therapy was derived from the engendered fear and that the patient, rather than submit to the periodic repetition of this fear, would find life less difficult if he returned to sanity. Other authors also attributed the therapeutic effect of metrazol to the experience of fear.

Kalinowsky (1956) points out in this connection that "the therapeutically ineffective tortures of previous times, and the ineffectiveness of painful electric stimuli used in psychotics prior to the shock era proved that fear could not be the effective agent, and when electroshock therapy was introduced this theory was abandoned".

With E.C.T. on the other hand, it was assumed that the experience was relatively bland for the patients who when "asked about their sensations affirm that they know nothing, simply having slept", (Cerletti and Bini, 1938). Even several years later authors such as Cook (1944) and Lewis (1943) were still impressed by the minimal presence or total absence of fear in patients undergoing electrical treatment. Abse (1942) was one of the first to stress the traumatic properties of E.C.T. He says: "The patient is being exposed to repeated danger situations and, unless he has become quite demented and introverted, he reacts by fear of this threatening external/

external danger...even in the absence of verbal formulation the patient's behaviour clearly shows during the treatment his desire to evade the repetition of the anxiety experience. The behaviourist and sensationalist would hardly discount the predominance of anxiety after observation of the pupils, pulse and respiration, etc. In short we cannot avoid the observation of fear."

Since this time reports of fear reactions have appeared in the literature (Friedman, 1957). In 1950 Cerletti recognised the presence of such affective correlates of the therapy which led some patients to want to stop treatment. When his patients were asked why they wished to stop treatment they were unable to give specific reasons other than that they were afraid. Further, they were unable to say of what they were afraid but nevertheless they were manifestly fearful of the treatment. Cerletti concluded that "there must be a vague recollection - organic memory - of the first 'terror defence' reaction. I believe that name 'terror defence' expresses the biological significance of epileptic fits. The terror phase, although taking place during unconsciousness, leaves specific biochemical and psychological changes in the organism that later emerge genetically into the conscious sphere." Gottesfeld and Baker (1946) found that as many as 80% of their patients treated by E.C.T. experienced fear. Fisher et al (1953) in an experimental study/

study of patients' attitudes to electroshock therapy reported that 25 of their 30 patients retrospectively indicated marked anxiety before treatment, 16 of whom said they had fears of dying before each treatment. Kalinowsky and Hoch (1952) authoritatively states that fear of E.C.T. was a greater problem than was originally realised.

Several studies have been reported in which specific interview material relating to an individual patient's fear of the treatment has been examined. Hayward (1951) gives a verbatim account of an interview with a female patient who had completed a course of 34 electroconvulsive treatments. This patient used the words "real terror" to describe her apprehension. Friedman (1957) presents extracts from the diary of a literate patient undergoing treatment by E.C.T. whose comments leave no doubt as to the presence of a very real fear of E.C.T. Friedman in discussing this material isolates four major fears which served to make the treatment a noxious experience for the patient:

1. Fear of punishment.
2. Fear of his helplessness.
3. Fear of humiliation.
4. Fear of what the treatment would do to his mind.

Friedman suggests that such reactions to E.C.T. are dynamically determined and that their meaning can best be comprehended by/

by "an understanding of those mechanisms which lie within the unconscious realm of the patient's psyche". The emotional response to the treatment, whether it be fearful, resigned, complacent, can be considered to reflect a particular defensive attempt to cope with a traumatic experience. Friedman further asserts that a full understanding of a patient's idiosyncratic reactions to E.C.T. may provide significant insights into the dynamics of his illness and, conversely, that an understanding of the dynamics of the illness may allow predictions to be made of the nature of his reactions to treatment. Fisher, Fisher and Nilkevitch (1953) examined such unconscious dynamic factors operating during a course of treatment by E.C.T. by asking patients to make up stories about a series of pictures so drawn that they could be interpreted either in terms of injury and death or in terms of rejuvenation. The change in the response to this test measured between two interviews, one at the beginning of the course of treatment and the other at the end, was interpreted either as a "pessimistic" or an "optimistic shift". On the basis of their finding that only one patient who improved and over half those who were unimproved showed pessimistic shift at the second test, they claim that improvement with E.C.T. is significantly related to attitudes to treatment. However, they offer no evidence about the extent/

extent to which pessimistic or optimistic shift depends upon factors in the illness itself and thus operate quite independently of the effects of E.C.T.

Investigation II above suggested that fear of E.C.T. was independent of diagnostic category and thus presumably of any constellation of unconscious factors. This does not fully rule out Friedman's emphasis on idiosyncratic unconscious elements. However, with the further finding that this fear was independent of response to treatment (contrary to the claims of Fisher, Fisher and Hilkevitch) it would seem reasonable to look to factors in the treatment situation itself rather than to personality variables in order to explain the fear of E.C.T.

Gallinek (1956) confirms this view and also corroborates the findings in Investigation II. He made observations on 100 patients before, during and after treatment by E.C.T. He found that 67 of these patients showed marked but various modalities of fear and that the remaining 33 showed appropriate fear (i.e. capable of being dispelled by information and reassurance). Table II gives surprisingly close agreement with these figures when the group reporting no fear at all is isolated (i.e. 16/50) but when appropriate fear is included it shows a reversal of Gallinek's figures, i.e. only 34% exhibited marked fear. Gallinek found no relationship/

relationship between proneness to fear and premorbid personality, tendency to recover, sex of patient or diagnosis. Depressive patients occasionally considered treatment as punishment and initially showed little fear, but came to dislike the treatment as they improved. He places the fear of treatment as arising in the recovery period and chooses to give an existential rather than psychoanalytical interpretation of the phenomenon. His hypothesis is that the basic anxiety characterising man's existence is normally neutralised by his sense of familiarity. In awakening from E.C.T. all recollected relations with the past and the ability to project into the future are extremely obscured. A temporary annihilation of the sense of familiarity after E.C.T. provokes basic anxiety and results in a strong, progressively increasing* fear of treatment.

The process of recovery from E.C.T. will be discussed more fully later. In general terms it is characterised by confusion and disorientation severe enough to represent a strong/

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* Footnote. This finding of a progressively increasing fear of treatment during a course of E.C.T. is confirmation of the hypothesised relationship between anxiety and latency via the convulsive threshold discussed subsequently in Investigation III. Holmberg (1954), for example, observed an increase in latency with progressive treatments, presumably related to the increasing fear and pre-treatment anxiety.

strong psychological trauma to the patient sufficient to occasion the strong fear reactions which seem specific to E.C.T. Several patients when discussing their fear of E.C.T. claimed to be able to distinguish between what they considered to be "normal fear" of medical procedures or of being anaesthetised and their specific dread of E.C.T. However, few of these patients spontaneously attributed their fear to the confusion experienced during the recovery period or even to any specific feature of the treatment procedure.

Some observations were carried out on the recovery of patients who had been anaesthetised for minor surgery in a casualty department. The intention in making these observations had been to make detailed comparisons between recovery of consciousness from routine anaesthesia and from E.C.T. However, this project proved technically and administratively unsatisfactory. Such observations as were made showed that, whereas the patient recovering from E.C.T. was unable to relate what had happened to him for a fairly long period during which he was apparently able to perceive events in his surroundings, the minor surgery patient re-established his orientation quickly either spontaneously or after a single explanation. The patient recovering from E.C.T. would continually ask what had happened to him but did/

did not react to the repeated explanation that he had just had treatment and was awakening. Whereas the patient waking up from an anaesthetic regains consciousness quickly and to all intents completely, the patient awakening from E.C.T. shows a slower partial and fluctuating recovery of consciousness.

It would seem feasible to implicate the recovery period as being the significant feature in producing fear of E.C.T. in spite of the fact that patients' reports do not seem to confirm this view. Because of the fundamental disturbance of consciousness at this time it is likely that there is a failure of registration of the content or circumstances which engender this fear, with subsequent dispersal or displacement of the experience.

BEHAVIOUR DURING CONVULSIONS

Most descriptions of E.C.T. revive Cerletti's statement that, when the electrical stimulus is applied, the patient responds with "a typical epileptic convulsion". The epileptic convulsion, however, shows many diverse phenomena and it is difficult to find a description of the reaction which could be regarded as typical. Penfield and Kristiansen (1951), for example, have elaborated the wide range of phenomena of the epileptic seizure pattern into a scheme for localisation and classification. The varieties of reaction which they describe in epilepsy are much wider than the reactions observed in therapeutic convulsions and the term "grand mal" does not accurately reflect the generalised convulsive reaction to E.C.T.

Investigation III

Observation of behaviour during the convulsion was made on a group of 35 patients composed of 21 women between the ages of 26 and 54 with an average of 42 years, and 14 men ranging in age from 28 to 51 with an average age of 41 years. The diagnosis in each case was affective disorder of a depressive nature and all the patients were being treated in an outpatient E.C.T. clinic. (This explains the low maximum age in both sex groups as the current policy of admitting older patients for treatment selected in favour

of/

of a middle-aged group.)

The standard course of treatment is usually eight convulsions given at the rate of two per week. This is a standard procedure for inpatients but for outpatients a course of treatment involving one E.C.T. per week is most often suggested. In the series examined, treatment was carried out once per week in order to interfere as little as possible with the patients' work. A relative attended with the patient to ensure that he did not experience any difficulty in travelling on public transport, or in being disorientated after the treatment.

The technique used in this clinic was that of the Plexacon apparatus devised by MacPhail and Strauss which produces an exponentially discharging steep wave form providing a series of stimuli of declining magnitude from the initial impulse which is of the order of 300 volts. These declining stimuli act as secondary stimulation should the first trigger prove inadequate to induce the convulsion. It has been shown that the convulsion threshold decreases in response to stimulation and the Plexacon apparatus was designed to maintain repetition of stimuli in such a way that a sequence of impulses would be given which would ensure the induction of the convulsive reaction. The advantage of the condenser discharge is that in any one treatment the

total/

total voltage applied to the brain is low while the high momentary electromotive force of the first wave is sufficient to overcome a wide range of skin resistances. The high initial trigger also reduces the possibility of error from faulty electrode placement. In former machines the trans-temporal resistance was crucial, meaning that the patient had to be scrubbed to reduce the relevant skin resistance. By the use of this steep-fronted wave form a wide range of skin resistance can be overcome and an electrode with a small surface area can be used without any danger to the patient. The electrode can be maintained in contact with the skin by utilising saline with no previous preparation of the patient's skin being necessary.

The standard procedure for Plexacon treatment is that the patient lies on a treatment couch, hairpins and dentures etc. are removed, tight clothing is loosened and a hard-packed cushion is placed under the mid dorsal region, ensuring that the spine is hyper-extended. The electrodes, fitted on a head-phone band, are placed so that their lower edge lies $\frac{1}{2}$" above the line drawn between the outer canthus and the superior attachment of the pinna, and at the junction of the anterior 1st and 2nd thirds of that line. A micro-ammeter fitted on the apparatus indicates the stage of the charge of the output condenser in joules. Having ascertained

that/

that a suitable charge is held on the condenser and that the patient is ready for the treatment, the stimulus is applied by depressing a switch. The application of the stimulus is accompanied by a flashing red light on the machine, indicating that the discharge has occurred. By restoring the switch to its normal position the machine is recharged for the next treatment. On this apparatus the wave form applied can either be monophasic or diphasic and a reading of 20 joules diphasic and 25 joules monophasic is considered to be adequate to produce a major fit. Strauss and MacPhail claim that monophasic stimulation gives a slightly quicker recovery rate than the diphasic stimulation which, by swinging its polarity, produces a more effective grand mal for any given charge. At this clinic only diphasic stimulation was used.

Observations were carried out on the 35 patients described above when they were undergoing the first treatment of a prescribed course on an outpatient basis. This first treatment was selected in order to avoid the effects of habituation or changes due to cumulative influences. A stopwatch was used to time the various phases of the convulsive behaviour, the watch being started simultaneously with the application of the stimulus.

The following general reactions were noted for the group as/

as a whole. On the average, three seconds after the application of the stimulus, a generalised tonic phase of the convulsion was initiated, the eyelids were closed tightly, the jaw muscles showed spasticity, the trunk assumed an opisthotonoid position, the arms were adducted and the legs and thighs were sometimes flexed. With the onset of this tonic phase half of these patients gave a loud cry. This general tonic spasm was maintained for about twelve seconds until the onset of the clonic phase was heralded by flickering of the eyelids. Clonic jerkings at a rate of three or four per second became more generalised until the clonic phase was fully established. The clonic phase was maintained for a further 18-20 seconds and then subsided. At an average period of 38 seconds after the application of the stimulus the convulsion was finished, and between one and three seconds after the last clonic jerking the patient began to breathe again. Once the physician was satisfied that breathing was free, the patient was removed from the treatment table to a recovery room where he was kept in bed under nursing supervision for a period of between 45 minutes and an hour, when he was considered to be adequately orientated. During this recovery period and especially in the first 20 minutes after treatment some patients became restless and abreactive (nine in the sample studied) but the majority/

majority remained in a deep sleep and responded readily to reassurance given on recovery.

Sulzbach et al (1943) reported a mean convulsion duration of 39.9 seconds and Finner (1954) found a slightly higher mean duration of 41.38 seconds, confirming the duration of convulsion noted above.

The observations of the course of the convulsive reaction are confirmed by Holmberg (1954) who used an electromyographic method of measuring convulsive behaviour during treatment. By plotting the amount of electromyographic activity recorded against the time after the beginning of the convulsion he was able to produce a curve showing the intensity of the convulsion (see Figure 1). This curve shows a fairly rapid increase up to about the eighth second after the beginning of treatment and the peak at about 12 seconds and thereafter a decline in the intensity of electromyographic activity. Further, by using this technique in a series of 39 cases and by comparing the intensity of the convulsion at the first shock with the intensities of subsequent shocks, he was able to show that the intensity of the convulsion and the frequency of the clonic jerks were more pronounced in the first treatment and decreased during subsequent treatment. In another investigation Holmberg (1954a) also applied his electromyographic method to investigate the influence of sex and age factors on the convulsions induced by electric shock treatment/

FIGURE I

Intensity of Convulsions

(from Holmberg, 1954)

treatment, and found that the duration of the convulsions and the relationship between the duration of the tonic and that of the clonic phase showed a high degree of constancy and were independent of age and sex.

Finner (1954) similarly found that the mean duration of the first convulsion was significantly longer than the mean of any other convulsion and again that duration of convulsion was independent of such factors as eventual outcome of treatment, duration of illness, presence or absence of previous E.C.T., age, weight, height and body surface area.

It was expected that the degree of violence of the convulsion would be related to general morphology and musculature and that men would be more likely to have violent convulsions than women. An attempt was made to rate the convulsions into three categories of strong, average and mild, and to relate this to sex differences and to general differences in bodily build. However, in this group of patients there was no significant difference in the strength of convulsion between the men and women or between the well muscled and poorly muscled patients. In fact, during this period of observation the strongest fit noted was in a small, underweight housewife of 44 while a burly labourer of 36, whose appearance in the treatment room called

for/

for extra nursing assistance to manage his convulsion, showed only a fit of moderate strength. Table V shows that the relationship between strength of fit and body build does not reach significance. Holmberg's (1954a) electromyograms on the other hand showed that the intensity of the convulsions was lower for women than for man, but the frequency of clonic jerks was higher for women than for men.

Table IV shows the observation made on the 35 patients during their first treatment by E.C.T. As was the usual practice on the patient's first attendance for treatment the physician carried out a brief explanatory interview. On the basis of this interview the physician was asked to assess whether he felt the patient was tense or not and, if tense, whether the degree of tension was appropriate or inappropriate to the treatment situation. These readings on a three-point scale are given in the table (0 = not tense, + = appropriately tense, ++ = inappropriately tense). In this group 20 patients (nine males and 11 females) were considered to have shown an inappropriate degree of tension before treatment.

Latency. The latency of onset of the convulsion was measured by recording the time in seconds between the pressing of the stimulus button on the machine and the onset of the convulsion. In this group three long latencies of eight, 10 and/

OBSERVATIONS DURING TREATMENT

(on 35 patients diagnosed as suffering from affective disorders)

Patient	Age	Sex	Height	Weight St.	Weight Lbs.	Body Build *1	Tense *2	Latency (secs.)	Time of cry (secs.)	Length of tonic phase (secs.)	Duration of fit (secs.)	Strength of fit *3	Disturbed Recovery
1	50	M	5'11"	12	12	H	++	5	-	10	42	+++	
2	28	M	5' 8"	10	9	M	0	4	-	15	40	++	
3	31	M	5'10"	10	2	L	++	2	4	8	38	++	
4	47	M	5' 9"	11	4	M	++	4	-	12	34	+	X
5	51	M	5'10"	11	12	M	++	0	-	15	45	+++	
6	36	M	5'11"	12	13	H	++	5	3	15	41	++	
7	50	M	6' 0"	13	13	H	+	0	3	7	40	+++	X
8	38	M	5'10"	13	9	H	++	6	-	15	37	++	
9	37	M	5' 9"	12	8	H	0	2	2	12	39	++	X
10	48	M	5' 8"	9	12	L	+	1	1	12	40	++	
11	40	M	5' 7"	12	3	H	++	2	-	18	38	++	
12	38	M	5' 4"	7	12	L	++	0	-	12	41	++	X
13	50	M	5' 9"	9	7	L	+	2	2	14	33	+	
14	30	M	5'11"	13	10	H	++	8	-	14	37	++	
15	44	F	5' 0"	8	9	M	++	5	-	12	39	++	
16	36	F	5' 1"	8	7	M	++	1	-	15	39	++	
17	26	F	5' 2"	6	10	L	+	4	5	12	34	+	
18	52	F	5' 6"	9	7	M	++	2	2	8	43	+++	
19	54	F	5' 4"	8	10	M	+	2	2	9	40	++	X
20	42	F	5' 5"	8	4	L	++	10	-	13	35	+	
21	51	F	5' 8"	10	2	M	+	1	1	12	42	++	
22	36	F	5' 0"	7	11	L	++	4	-	12	40	++	
23	34	F	5' 3"	8	4	L	0	2	2	12	34	+	
24	38	F	5' 2"	8	9	M	++	4	-	10	43	+++	X
25	39	F	5' 5"	7	10	L	++	0	1	13	37	++	
26	44	F	5' 5"	8	2	L	++	4	-	10	41	++	X
27	52	F	5' 0"	6	11	L	+	5	-	15	40	++	
28	49	F	5' 0"	6	4	L	++	15	-	12	37	++	X
29	43	F	5' 3"	9	6	L	0	5	-	9	39	++	
30	44	F	5' 3"	6	5	L	++	6	-	15	44	+++	
31	47	F	5' 2"	7	7	L	+	1	3	15	33	+	
32	43	F	5' 6"	8	10	L	++	4	-	14	40	++	
33	38	F	5' 2"	7	11	L	+	3	5	12	34	+	
34	35	F	5' 4"	7	5	L	++	5	4	12	35	++	
35	46	F	5' 8"	9	4	L	+	3	-	10	37	+	

*1 Estimated from Documenta Geigy Scientific Tables (5th Edit.)
H = Heavy, M = Medium. L = Light.

*2 Rated by the physician immediately before treatment.

*3 Rated by the nurses assisting during treatment as

strong +++, moderate ++, mild +.

and 15 seconds respectively were noted.

Time of cry. Sometimes during the convulsion a cry was noted. Fifteen patients were observed to have made this cry which can vary from an expirational grunt to a long, crescendo, full-mouthed wail. The time at which this cry was heard was noted. The results show the cry to occur well within the tonic phase and it would seem that the cry is due to respiratory spasm.

Duration of fit. Duration of fit was measured as the time between the beginning of the convulsion and the point at which breathing was restarted.

Strength of fit. This was rated by experienced nurses in the clinic on a three-point scale as mild (+), moderate (++) and strong (+++).

Disturbed recovery. While the patients were recovering they were observed and any disturbance such as thrashing movements, restlessness, tearfulness, abreaction, shouting or violence was noted. Eight cases were considered to have shown a disturbed recovery, the remainder being peaceful.

The observations in Table IV were examined for contingency by the method of X^2. Although the original observations had occasionally been made on a three-point scale, it was felt that the X^2 test would be more properly applied where the numbers were so restricted by using one degree of freedom only. Accordingly the three-point scale was split about/

about the middle rating and all the probabilities were calculated for one degree of freedom (see Appendix C).

Table V shows the probabilities calculated from the contingencies derived from Table IV.

Only two relationships are seen as significant, viz. that between the strength of the fit and its duration (significant at the 0.05 level) and the more significant and more interesting relationship between latency and pre-treatment tension (at the probability level of 0.03). This observation would suggest that there is some relationship between tension and the delay between the stimulus and the beginning of the convulsion.

This latency is reported by experienced clinicians and may sometimes last for periods of about a minute. The delay is often disturbing to those administering the treatment and may lead to an assertion that the machine sometimes is faulty. However, the delay occurs even although the stimulus has been correctly applied and clinicians vary in their opinion as to its frequency of occurrence. Some would claim that certain patients are more likely to give long delays in their treatment than are others. Kalinowsky and Hoch (1952), however, state that there seems to be no accepted explanation for this latency.

There would seem to be two problems involving different forms/

TABLE V

Probabilities calculated from contingencies derived from Table IV
(See appendix C)

	Body Build	Latency	Tension	Duration	Strength	Disturbance
Body Build	-	0.48	0.6	0.6	0.69	0.72
Latency	0.48	-	0.03	0.45	0.7	0.4
Tension	0.6	0.03	-	0.48	0.2	0.78
Duration	0.6	0.45	0.48	-	0.05	0.37
Strength	0.69	0.7	0.2	0.05	-	0.9
Disturbance	0.72	0.4	0.78	0.37	0.9	-

forms of latency. One is the unpredictable excessive latency where long delays of 30 seconds or over are observed and the other is the smaller but still measurable delay which may possibly be related to pre-treatment tension. It is this latter shorter delay period which will be discussed.

Discussion

The phenomenon of latency can be viewed as being related to the convulsive threshold, hypothesising that the higher the threshold the longer the latency. Previous work has suggested that this convulsive threshold depends on several factors. Kalinowsky and Hoch (1952), for example, report the threshold to be higher in older patients, in women, to rise with progressive E.C.T. and to be highest on cold dry days. Kalinowsky and Kennedy (1943) have also suggested that there is possibly an initial inhibitory period which precedes a major convulsion. It is not clear what significance could be attributed to this suggestion other than an attempt to explain variations in excitability determining the convulsive threshold. What is required is a postulated relationship between disturbed and agitated behaviour and the increased threshold.

Jeans and Toman (1956) carried out a series of observations/

observations similar to those above on 48 consecutive patients (10 men and 38 women) with an age range of 24 to 77 years and using specially devised rating scales. Before treatment the patients were rated on three ad hoc scales, a) the anxiety scale, b) the depression-elation scale, c) the dissociation scale. Latency was determined by simultaneously pressing a stopwatch and the "treat" button of the E.C.T. machine. They found again that seizure latency was highly correlated with the level of clinical anxiety immediately preceding E.C.T., greater anxiety giving a longer latency. Further, they confirmed Kalinowsky and Hoch's assertion that in older patients significantly longer latencies were observed and that the latency was longer for women than for men. Variations of room temperature and humidity within ordinary limits, however, were found to show poor correlation with the latency. They concluded "it is possible to deduce that anxiety in particular increases latency simply by raising the threshold and that threshold is probably an important factor also in the differences seen with age, diagnosis and cumulative E.C.T".

The relationship between latency and tension in terms of threshold can only be explained if account is taken of the cerebral concomitants of tension or anxiety. This is a highly speculative task and it is only recently that indications/

indications of significant central mechanisms underlying anxiety have been postulated. Disregarding for the moment any possible pathway or mechanism involved, there are some suggestions that anxiety may be associated with an alteration of the threshold of the cerebral hemispheres. In extreme anxiety reactions there are indications that inhibiting factors may operate as seen, for example, in fainting. Pavlov (1928) directed attention to such inhibition when he discussed the role of induced and trans-marginal inhibition in responses to stress. Freud (1936) remarked that "inhibition follows anxiety like a shadow". It is recognised too that auditory, photic and somesthetic stimulation may produce spontaneous seizures or electro-encephalographic seizure records in some patients and, in fact, such procedures are routinely used in E.E.G. examination. In the epileptic patient any sudden or intense emotional stimulation may occasionally activate seizure discharges.

Linn (1953) discusses such observations and extends the conventional psychosomatic or psychoanalytic views of the effects of emotional factors in precipitating grand mal seizures. He assumes that anxiety arising from the activation of strong repressed feelings tends to favour massive cortical discharge. In doing this he is to some extent guilty of/

of confusing the fiction of libidinal energy with neuro-physiological activation. However, the speculation he offers is valuable when he supposes that the effect of anxiety is to deactivate the ascending reticular system.

Clinical evidence of this sort is only one part of the picture. Various other conditions of a depressant nature such as hypoglycaemia, fatigue and sleep may favour the appearance of seizure discharges in the E.E.G. (Walter, 1950). Many epileptics, for example, have their seizures only during sleep or the first symptoms of their convulsive disorder may appear as a sleep disturbance.

Penfield and Jasper (1954) give direct evidence, however, that attention or arousal may block seizure discharges and that cortical stimulation may extinguish or suppress local seizure discharges. Such findings are related to normal desynchronisation of cortical rhythms observed during the recording of an E.E.G. This phenomenon relates to one of the earliest findings by Berger that in a relaxed state and in the absence of stimulation the dominant activity is a rhythmic (synchronous) 10 per second alpha rhythm. When, however, sensory stimulation is introduced the alpha rhythm is blocked, producing desynchronisation of the multi-cellular rhythmic beat. Such desynchronisation or activation of the cortical E.E.G. with some related behavioural arousal is attributed

to/

to the action of the ascending reticular system. Lindsley (1952) shows that apprehension or tension can similarly result in desynchronising the spontaneous E.E.G. rhythm and asserts that emotional arousal or activation is determined by the action of the diffuse ascending reticular system.

While it would seem that there is evidence enough to favour the view that an alerted or an aroused state may produce a higher seizure threshold, the role of anxiety is still not clear. Animal experiments have shown that shock latency can be increased by introducing stressful procedures immediately before the administration of the stimulus and reduced by previously administering the tranquillising drug reserpine (Jeans and Toman, 1956). It is tempting on the basis of such evidence to conceive of a negative feedback circuit from cortex to reticular system and thence back to cortex by means of which anxiety can produce desynchronisation of cortical rhythms and thereby raise the cortical threshold. Unfortunately the electrophysiological evidence for such a mechanism in anxiety is by no means complete. The most efficient way of producing desynchronisation in the human E.E.G. is to introduce a patterned stimulus, generally visually, but there is no work to suggest that there are any affective correlates of this stimulus which could indicate that anxiety can operate in such a situation. The question still to be answered/

answered is whether anxiety itself is specifically capable of producing the necessary state of alerting.

The Nature of Anxiety

The conventionally held concept of anxiety is by no means inconsistent with such a mechanism although the crucial experimental evidence is still lacking. Anxiety is held to be a biological signalling system originating from a fundamental state of disequilibrium in the organism and in this sense could be considered to be an alerting agent. May (1950) asserts that "man's creative abilities and his susceptibilities to anxiety are two sides to the same capacity". Biologically the mechanism of anxiety is vital and may be viewed as one aspect of the activity of regulatory mechanisms which serve to maintain awareness under conditions of stress.

Our basic notions of anxiety derive from Freudian theory which depends largely on a concept of "psychic energy" and on Breuer's distinction between the "free" and "bound" forms of this energy. The early Freudian theory held that anxiety was derived from repressions of libidinal drives, exploiting their energy. From this formulation the operation of unconscious anxiety could be postulated as being crucial in the origin of psychopathological states, initiating and maintaining a regressive process or an ego-disruption. In his later and metapsychological treatment of anxiety Freud offered the

more/

more "biological" view that anxiety represented a signal within the ego providing warning of the presence of unacceptable or nonpleasurable energies, and whose prototype was the helpless infant's call for help.

There are thus two fundamental forms of anxiety - the psychopathological (traumatic) and the biological (signalling). In clinical terms it is difficult or perhaps even impossible to discriminate these forms. Patients may show many gradations of increasing amounts of anxiety from traumatic disruptive reactions to excessive signalling or "homeostatic" anxiety which is milder in degree. The related experience of fear may be difficult to distinguish from anxiety although at the level of conscious experience the term anxiety can be used to refer to the "unattached" or "objectless" reaction, fear referring to the reaction to a specific threatening object or situation.

These represent inferential and even speculative formulations of the "inner" origins of anxiety. Anxiety, however, is part of a stress reaction which is initiated by a variety of stimuli - perceptual, interpersonal, intrapsychic and even somatic. Whatever their origin, the stimuli produce preparatory or emergency reactions against threat which may or may not be fully adaptive.

The experimental approach using animals allows the characteristics of the stimuli or precipitating events to be more/

more clearly differentiated. Riech (1956) presents three such characteristics:- " 1) the more or less sudden arrival of information of environmental response inconsistent with the information the anticipatory behaviour is, as it were, prepared for; 2) arrival of information previously associated with situations inevitably (i.e. regardless of any performance the animal is capable of) including 'pain' or 'doom'; and 3) change in rate or in variability of information such that the interacting system becomes overloaded and functionally disorganised." These characteristics are badly expressed and could be more clearly given as:- 1) inconsistency of the actual with the anticipated information; 2) predetermined or conditioned stress responses; 3) excessive form or patterning of stimulation. Expressed in this way these characteristics describe the classical methods of induction of experimental neurosis in animals by workers such as Gantt (1944), Massermann (1946) and Liddell (1956).

The interesting and relevant theoretical point which arises in this connection is that there is some relationship between the emergency or alarm system and the anticipatory and information selecting system. If this is so it suggests that anxiety operates in an alerting fashion. This would seem discordant with the previously discussed inhibitory nature of anxiety, but in the light of the distinction between the two kinds/

kinds of anxiety one can assume that "traumatic psychopathological" anxiety may be inhibiting while biological anxiety, signalling a state of disequilibrium, is alerting. If this is so, there is some justification for considering the effect of anxiety on the convulsive threshold in terms of the operation of the reticular activating system (see Section III).

RECOVERY OF CONSCIOUSNESS AFTER E.C.T.

In Investigation III the behaviour of patients during the therapeutic convulsion was described. At the end of the convulsion, indicated by the termination of the clonic phase, and once spontaneous breathing is established, the patient is unconscious and the recovery period begins. This recovery phase will now be examined as it involves a process of restoration of the patient's cognitive and perceptual functions and a re-integration of his personality. It is also interesting to consider whether this recovery process occurs in a form specific to E.C.T. or common to other medical procedures in which consciousness is reduced or lost and subsequently recovered.

The nature, significance and terminological difficulties of consciousness and unconsciousness will be discussed later (Section III). For the moment the term conscious can be taken to refer to the state in which an individual manifests a number of psychological functions all of which determine in a demonstrable fashion his adjustments to environmental change. Unconsciousness then refers to a state in which such functions are not operative. In behaviourist terms complete unconsciousness represents a state in which the individual is unresponsive. E.C.T. can be regarded as providing an artificially/

artificially induced, transient alteration of the conscious state under conditions which permit examination of the recovery processes.

Head (1926) suggested that when functions disappear, as a result of the administration of an agent such as chloroform, they are lost "in order beginning with those of highest rank, and culminating with the most mechanical and predordained responses". He also suggested that there was a reciprocity between the regression from and the recovery of consciousness in that both processes followed the same steps but in opposite directions. In the field of shock treatment Himwich (1951) confirmed Head's observations when he examined the return of neurological function during the recovery period in insulin coma treatment. There is also relevant experimental evidence from animal studies. Wilcox (1955), for example, quotes the work of Yoshii and Hiraiwa on rats which demonstrates that in the post ictal state the pattern of the simple spinal flexion reflex returns before its modification by the brain stem and, further, that recovery of both these functions precedes any demonstration of influence of cortex.

Cohen (1939) reported his observations of a schizophrenic patient during the hour of recovery after metrazol-induced convulsions. He noted that reactions to painful stimuli returned/

returned first, then the fixation and maintenance of attention and the correct naming of objects, followed by a correct appreciation of their use, then the execution of complex, co-ordinated movements and finally the return of memory. Cohen concludes that "cognitive functions reappear in a characteristic temporal order, indicating the dependence of a given function on preceding ones". His observations, carried out as they were on one patient only, hardly justify the generalisation he offers; nevertheless his conclusion accords with those of other workers previously quoted.

Lunn and Trolle (1949) studied the initial impairment of consciousness following E.C.T. by asking their patients a series of questions and presenting them with a series of tasks at intervals of 10 minutes, 30 minutes, 60 minutes and 120 minutes after shock. Their questions and tasks were designed to elucidate the degree of recovery at each of these intervals of such features as the patients' autopsychic and allopsychic orientation, body orientation, attention, apperception, content of memory, retention, ability to name objects and arithmetical ability. By this means they were able to discover the relative fate of each of these elements by examining the recovery of consciousness of 10 women and 11 men being treated by E.C.T. for affective illnesses. The results show that:-

1)/

1) Name and marital state show the greatest resistance towards general impairment of consciousness after shock. Awareness of age, however, seems to be particularly vulnerable; 10 minutes after the shock 90% of the patients can give their name while only 10% can give their age; as much as two hours later there is still considerable confusion about age.

2) Orientation in space is established gradually during the two hours after shock and is completely normal at the end of this period. Orientation for time, however, is more vulnerable as two hours after shock over half their patients were unable to say for how long they had been in hospital.

3) Retentive memory is disorganised after shock. An hour after treatment only 15% of their patients could retain numbers with four digits after a filled interval (some distracting task had been presented between the presentation of and recall of the digits). However, there was only a slight reduction in the power to mobilise previously memorised matter.

4) Retrograde amnesia was observed in half of the patients 30 minutes after shock. This, however, disappeared by the next appraisal. It seemed that the period covered by the amnesia did not diminish gradually but that the re-establishment of memory was sudden and total.

5)/

5) These specific psychological changes were found to occur independently of the changes in ability to perceive. Thus the negative findings on specific tests are not due simply to a generalised disturbance of perception.

Wilcox (1955) in a similar study measured changes in intellectual functioning by administering a battery of varied tests serially at 15-minute intervals after E.C.T. Observations were carried out on 51 psychotic female patients diagnosed as suffering from manic-depressive, involutional and schizophrenic reactions. The process of their recovery was studied by questions designed to elicit information of the patients' recognition of self, of other persons, of place and time, the first questions being asked as soon as the subject was capable of making a verbal response. She found that awareness of name appeared to be almost but not quite identical with the return of consciousness and speech, for in 64 out of 66 observations patients gave their own names clearly on awakening. At 15 and 30 minutes after the treatment orientation for place, for other persons and for time showed a consistent loss and at 45 minutes after treatment orientation for time was more frequently diminished than any of the other features observed.

These two studies show that the post-shock somnolent state is suitable for an analysis of the psychopathological features of impairment of consciousness. It is possible to obtain/

obtain psychological data about the patient before the pathological condition is induced and the relatively rapid re-establishment of consciousness allows a continuous examination of psychological changes. The method also allows the possibility of repeated analysis of the same patient at subsequent treatments.

There are two possible methods of carrying out this examination:- (a) as in the above quoted studies by a transverse periodical evaluation of a number of psychological functions at prearranged times, (b) by a continuous examination of the patient from stupor until the re-establishment of consciousness. This latter procedure requires a special technique whereby the tempo of the examination of the patient reflects the rate at which his psychological functions return. If such a precaution is not taken the patient's recovery process will continue without its changes being reflected in his responses.

Investigation IV

It was decided to investigate the recovery of consciousness from E.C.T. by a continuous examination of the process rather than the periodic assessment undertaken by Lunn and Trolle. While it was realised that a global or Gestalt approach would have been more consistent with theoretical views, the elementarist or atomistic approach was chosen because it allowed the examination of the patient to be a more active and/

and transactional relationship and to be capable of being structured.

On the basis of Lunn and Trolle's work a list of questions and tasks was prepared to cover the following functions:-

Personal orientation - Name, address, age, marital status.

Personal orientation - Place, time, date, circumstances, right-left orientation.

Memory - Place and year of birth, name of school, father's name, retention of digits.

Perception - Description of pictures, naming of objects.

The list comprised the following:-

A
1. What is your name?
2. Where do you live?
3. Where were you born
4. Are you married?
5. What age are you?

B
6. What year were you born?
7. What school did you go to?
8. Identify common objects (pen, pipe, matches, tie, knife, keys, safety pin).
9. Tell me your father's name.
10. Description of pictures (five quarto-sized, coloured pictures of a factory interior, haymaking, mountains, seaside, river).

C
11. What is today's date?
12. What school did you go to?
13. What year is it?
14. What time of day is it?
15. Right-left orientation (asking patient to indicate laterality of hand, eye, ear, foot).

D
16. Digit repetition.
17. Who am I?
18. What place is this?
19. Sentence repetition (three alternative sentences of 20 words each).
20. Arithmetic problems (simple subtraction, multiplication, shopping problem)

This list could be answered by the conscious patient in 2-3 minutes but took considerably longer for the recovering patient. The order of questions was designed to approximate to the sequence of recovery found by Lunn and Trolle and was checked by examining several patients recovering from E.C.T. at the outpatient clinic. It was realised that the order of questions could in fact determine the order in which the recovery of functions was noted. To avoid imposing a rigid pattern upon the observations a technique of questioning was devised/

devised which allowed the interview to remain continuous without seriously reducing the standardised nature of the examination.

The questions were grouped in fives. The first five questions were asked, each being repeated if at the end of five seconds there was no answer. If at the end of the first five questions (group A) no answer had been given, the whole group of questions was asked again. If, however, any question in this group was answered, or after the group had been repeated, the investigator proceeded immediately to group B. He then repeated group B if no answer was given, but proceeded to C if any question in group B was answered and after group B had been repeated. In this way the whole list of questions was worked through and continuously altered as answered questions were deleted. Several times during the interview, however, the correctly answered questions were reintroduced to check that the correct answer could still be obtained. The interview ended when all questions had been answered or when there seemed to be little chance of obtaining an answer.

Observations were carried out on 30 female patients diagnosed as suffering from depressive disorders and receiving E.C.T. as inpatients. (The fact that the group was a female group arose out of administrative considerations - viz. that the treatment was given to female patients in a room which could/

could subsequently be used with the minimum of interruptions for prolonged observations. To carry out such examinations on male patients would have meant transporting them on trolleys through the hospital to a vacant room. Portering delays and the risks involved in moving patients immediately after treatment made it more convenient to carry out the investigation on female patients only. No significant sex differences were, however, expected.)

Patients were seen immediately E.C.T. was prescribed, generally several days before their first treatment. At this initial interview the nature of the treatment was explained and they were told that they would be asked certain questions while they were coming round from their treatment. The investigator introduced himself as a psychologist especially interested in this type of treatment and asked for the patient's co-operation. He then obtained the basic data necessary to judge the patient's responses to the prepared questions, for example, year of birth, name of first school attended, father's name, etc.

At the treatment session the investigator brought the patient into the room and assisted at the administration of the E.C.T. Once the convulsion was completed and the patient's breathing satisfactorily re-established she was moved to a bed in the recovery-room and observations of the recovery period

were/

were undertaken, being timed in minutes and seconds from the application of the stimulus. This previous contact with the patient was deliberately made in order to establish the investigator as a familiar figure and thus reduce any trauma to the patient which might have arisen from encountering a stranger upon awakening. It was realised that this contact with the investigator might possibly enhance the patient's ability to reorientate herself as his presence would be related to the treatment situation.*

In order to make observations of the recovery process it was sometimes necessary to initiate awakening as the patients might otherwise have remained asleep during the whole interview. If the patient did not waken spontaneously five minutes after the shock, finger-snaps were used to rouse her. She was then greeted and questioning began.

Questions/

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* Footnote. It should be pointed out that transference to the investigator was unusually high during this investigation. This occasions the reflection that the conventional practice of detaching E.C.T. from the psychotherapeutic situation is probably uneconomical. An hour's contact with the patient during the recovery period from E.C.T. would seem to yield more positive transference than a similar time spent in the early stages of psychotherapy. The value of the doctor-patient relationship during recovery from insulin coma has, of course, been annotated; it would seem that the recovery from E.C.T. could be similarly exploited.

Questions were asked in a level but insistent tone of voice. After a question was asked, a five-second interval was allowed and if there was no response it was repeated and a ten-second interval elapsed before the next question was presented. The time at which the question was posed, the answer and the time of answering were noted on a prepared form. The following protocol gives a characteristic record of this kind of interview.

The patient was a 31 year old married woman with one child. Over the previous six months she had shown signs of moodiness, irritability, loss of interest, lack of concentration, disturbed sleep rhythm, indifferent appetite and had neglected her appearance and housework. She had been admitted to hospital after announcing to her husband that she intended to commit suicide. In hospital she remained depressed and tearful, was apathetic and unwilling to participate in psychotherapy. However, she consented to have E.C.T. and was eventually discharged as much improved after a course of 10 E.C.T., the first two being daily and the remainder at twice weekly intervals. This interview took place after the first treatment of this course.

+0 seconds. Current applied. Immediately tonic phase begins with arms extended.

+2 seconds. Slight inspirational sound.

+5/

+5 seconds.	Clonic eye jerkings begin.
+10 seconds.	Clonic phase fully established with moderate arm and leg movements. (Fit rated as mild.)
+34 seconds.	Convulsion ends with spasmodic jerkings.
+36 seconds.	Cyanosed appearance - but breathing is established immediately and spontaneously.
	Removed to recovery-room.
+2 minutes.	Lies asleep with head turned to one side.
+5 minutes.	No movement. Sleeps peacefully with slight snoring
+5'30"	Eyes open sluggishly in response to finger-snap. No response to greeting.
+5'45"	Opens eyes and turns to examiner quickly in response to "Look at me". Says "Hello" and smiles.
+6 minutes.	Gives correct number of fingers held up by examiner.
+6'10"	Gives maiden name.
+6'30"	Says she has forgotten address.
+6'40"	"Are you married?" "No."
+6'55"	"Where were you born?" "I think I've forgotten."
+7 minutes.	"What year were you born?" "I don't know."
+7'10"	"What is your name?" Answers correctly (married name).
+7'15"	"Where do you live?" "I don't know, I've forgotten
+7'25"	"Where were you born?" "Whalley." (correct)
+7'30"	"Are you married?" "No."

+7/

+7'35"	"How old are you?" "I don't know."
+7'45"	"When were you born?" "Whalley."
	"What year were you born?" "19-- was it? I've forgotten it."
+7'55"	"What school did you go to?" "It was in-- Whalley Range."
+8'05"	Names pen, pipe, matches correctly.
+8'30"	"What is your father's name?" "Frederick-----"
	"Frederick what?" "Frederick--- W." (i.e. her own married name).
+8'45"	Shown picture - Responds correctly that it is about haymaking in the country.
+9'05"	"What is your address?" "Twenty - something."
+9'15"	"Are you married?" "Yes."
+9'25"	"How old are you ?" "I don't know."
+9'35"	"What year were you born?" "1920 something."
+9'45"	"Tell me your father's name?" "Frederick L." (correct)
+10 minutes.	"Where are you now?" "In the Infirmary of course."
+10'15"	"Who am I?" "Oh, I know you."
	"Who am I?" "Oh, I've seen you before in the ward."
+10'35"	"What is today's date?" "1st August." (actual date - 13th November, 1952).
	"What year?" "I don't remember it."

+10/

+10'40"	"What day is it?" "Thursday." (Wednesday).
+10'45"	"What time of day?" "Morning."
+11 minutes.	"What year were you born?" "I've forgotten."
+11'15"	"Where do you live?" Gives parents' address.
	etc. etc.

This excerpt from one interview is quoted to illustrate the technique of questioning used whereby the unanswered or incorrectly answered questions are returned to and represented. Thirty-five minutes after shock Mrs. W. was still unable to give her age although she gave the current year correctly and her date of birth. She was unsure of the date but she knew the day, circumstances of her illness and treatment. She had been able to do the arithmetic problems set for her and could repeat a sentence of 20 words, and six digits. It was not until 48 minutes after the shock that she gave her age correctly. At the end of the interview she said she felt well and returned to the ward walking but accompanied.

Results

Table VI presents the results of the investigation of the recovery process in the group of 30 patients by showing the average time for the whole group at which correct answers to the questions were noted. The order of recovery is seen to be: Name, marital status, address, birth place, name of school/

TABLE VI

Recovery of Consciousness. Time of Correct Responses

	Average Time (to nearest minute)	Approx. Range (mins.)
Response to examiner	4	2 - 6
Name	5	2 - 9
Address	8	6 - 21
Marital status	8	3 - 17
Where born	10	6 - 18
Year of birth	18	10 - 34
Age	48	26 - 90+
Father's name	20	9 - 35
Name of school	14	8 - 19
Describe picture	25	7 - 30
Orientation for place	27	16 - 36
Orientation for date	51	13 - 90+
Orientation for year	47	13 - 65
Orientation for examiner	20	14 - 23
Right-left orientation	35	25 - 62
Arithmetic problems	45	30 - 70
Sentence repetition	47	38 - 90+
Digit Repetition	20	13 - 26
Identifying objects	18	12 - 29

school, year of birth, object identification, father's name, digit repetition, orientation for examiner, picture description, right-left orientation, arithmetical problems, orientation for year, sentence repetition, age, orientation for date. It could be argued that this order merely reflects a random occurrence within this group. However, the group consistency can be checked by taking the range of times of appearance of each feature, also given in Table VI, and correlating the rank order of the lowest and highest times with the rank order of the average for the group. Positive and significant correlations will then signify that this pattern appears consistently throughout the whole group.

In Appendix D these observations are ranked and the correlations calculated by the rank difference method. This yields correlation coefficients of +0.79 between the average for the group and the lowest times and of +0.87 between the average and the highest times. These high positive correlations suggest that the pattern of recovery is consistent within the group observed.

Discussion

Autopsychic orientation. This refers to such items as name, marital status, address, birth place, school and year of birth, all of which appear to recover earliest. The ability to/

to respond with one's name coincides virtually with the point at which the first response is noted. There is, of course, the complication that within this group selected some married women gave their maiden names before married names. In the excerpt of the interview quoted, for example, the patient, although she had been married for several years, first of all gave her maiden name. Out of the 30 patients, 23 were married and of these, 10 gave maiden names before they gave their correct married names. This phenomenon seemed to occur independently of the expectation that more recently married women might confuse their names than would those who had been married for a long time. It could be suggested on psychoanalytical grounds that the response with a maiden name was psychopathologically determined by an unconscious rejection of the marital role. This did not seem to be the case from the clinical data available, but no pronouncement can be offered on this interpretation as systematic studies of psychodynamic material were not undertaken.

It was observed that certain incompatibilities could occur, even in answers in juxtaposition. This was reported (Mowbray, 1954) as an example of the state of entertainment of incompatible propositions described by Pick in amnesic states. For instance, a patient would give her maiden name, but would say that she was married and would give her husband's surname correctly. Immediately afterwards, on being asked her name, she/

she would give her maiden name again.

Disorientation for age, a similar phenomenon, can be observed in the recovery period from E.C.T. Of all the items of personal orientation, awareness of age shows the longest delay in recovery. Such disorientation persists after awareness of year of birth is expressed and, in some patients, even after awareness of the current year is also evidenced. Weinstein and Kahn (1950, 1951) describe such disorientation for age in two cases of alcoholic Korsakow psychosis in which both patients were orientated for year of birth and current year yet underestimated their ages by 16 years and 10 years respectively. Zangwill (1953) views this tendency to maintain disorientation in the face of contradictory evidence as illustrating Pick's entertainment of incompatible propositions because, even although able to do the arithmetical reasoning involved, these patients did not accept the result as their "actual" age. In the recovery of consciousness after E.C.T. the presence of a similar but transient disorientation for age suggests that orientation for age is not dependent upon arithmetical inference from knowledge of current year and year of birth.

It is interesting to consider a possible "psychology of knowing one's age" in terms of this pathological phenomenon. One would assume that in general such factors of personal identity/

identity as age would have stronger psychological force than simply the results of an arithmetical calculation, and would be a more or less significant ego-component. The factors which render orientation for age "more or less" significant may be motivational (in terms of social values ascribed in certain situations to being "young" or "old" or in the feminine reluctance to divulge her years!). Learning or rehearsal effects can also operate in that at certain periods one's age is made explicit, for example, in entering contracts such as for insurance, marriage, employment and so on, or even in celebrating birthdays.

Returning to the symptomatic disorientation for age, Zangwill holds that denial of age in amnesic patients has the function of allowing the individual to maintain as stable and consistent an orientation to himself as his cerebral condition permits. In terms of ego-psychology the individual is trying to maintain the greatest possible intactness or integrity of his ego.

However, if we assume an organised body of memories which can be ordered in time as one requirement of the integrated ego then it is difficult to reconcile the incompatible orientations encountered after E.C.T. If the desire to maintain intactness of the ego were wholly operative then one would expect that, depending upon the degree of recovery, a psychologically/

psychologically consistent if inaccurate pattern of orientation would be presented, viz. that the married woman might give her maiden name, her address before marriage and state she was not married.

The resemblance between the post-E.C.T. and the Korsakow state already mentioned leads to wider biological and psychological implications. Indeed E.C.T. has been reported as being capable of producing a Korsakow syndrome both transitorily and sometimes, in arteriopathic patients for example, of a more permanent nature. Roth (1952) has marshalled clinical and electroencephalographic observations to suggest that the primary effects of E.C.T. occur at the level of the diencephalon where the Korsakow pathology is also held to occur. The main evidence for this assertion came from serial E.E.G. examinations of patients undergoing E.C.T. which suggested that a cumulative influence was being exerted on some mid-line structure with access to all cortical areas and with some special relationship to the frontal lobes.

As before the discussion leads to the implication of some mid-brain function in the effects of E.C.T.

Allopsychic Orientation

This heading refers to the conventional orientations as assessed clinically for whereabouts, time, date, etc. which in the group studied took longer to return than autopsychic features.

The/

The distinction between what in general terms can be called personal orientation and temporal orientation can be taken to reflect the ontogenetic development of orientation itself. The work of developmental psychologists such as Piaget and Werner indicates that the fundamental distinction between "me" and "not me" determining awareness of self as an entity separate from others is the result of a protracted process. Piaget suggests that even at the age at which the child is capable of spontaneous play there is evidence in the content of his games that he is not differentiating between himself and the environment. However, it appears that, although it develops relatively late, recognition or identification of self precedes the recognition of other persons. The notion of temporality and orientation for time is a still later development, dependent at least for its expression upon an ability to conceptualise.

If this developmental formulation is accepted then it would seem that the difference in recovery of autopsychic and allopsychic orientation would reflect a difference between less mature and more mature functions. This general possibility will be discussed in relation to specific features of allo-psychic orientation.

Disorientation for time or disturbance in time discrimination are not isolated or specific symptoms.

A/

A pathological time sense or time agnosia can be observed in patients suffering from organic psychoses, the distortion of time sense possibly being related to the distortion of memory (Dubois, 1954). Cohen (1950) goes further in suggesting that in organic brain disease the disturbance of time sense is a characteristic feature of the generalised impaired capacity for organisation. The disturbance of time sense is difficult to demonstrate as the patient will eventually orientate for time using environmental cues. However, what seems to be disturbed is the patient's "feeling for time" which normally operates independently of such cues. Thus the patient can "know" the time of day by reflecting that it is after breakfast and before lunch but outside such inference does not feel "that it is any time". The phenomenon of displacement of events in time characteristic of the Korsakow psychosis which involves a disordered memory for time is noted in patients during a course of E.C.T. and will be discussed later.

Orientation for the examiner is another significant feature which can be discussed under the heading of allo-psychic orientation. It will be remembered that in this investigation a preliminary interview with the examiner was deliberately arranged in order to avoid any traumatic effects on the patient during the recovery period. The investigator's role/

role was explained to these patients and when the patients met the investigator in the treatment room they recognised him and accepted his role and interest in them. However, in the recovery period several of the patients, while affirming that they recognised the examiner as a familiar person, were unable to state his function or profession, although they were subsequently able to say exactly who he was. This phenomenon was originally regarded as being related to a basic memory disturbance in which recognition of the examiner was displaced to an inappropriate situation. However, a paper by Max Levin (1956) on thinking disturbances in delirium offers another possible interpretation.

Levin describes how the delirious patient, being disoriented for person, may be unable to name the physician's vocation on command, yet may spontaneously and unwittingly address him correctly. One intriguing example quoted is of a patient who, when asked to say that the examiner's work was, replied in embarrassment: "I wouldn't know, doctor, is it painting and decorating?" This paradoxical phenomenon resembles closely the kind of partial orientation for the examiner noted in patients recovering from E.C.T. Levin deals with this as paralleling the situation in motor aphasia in which the patient fails to perform on command tasks which he can spontaneously perform with ease.

In/

In Jacksonian terms the distinction is made between the automatic (or least voluntary) and the voluntary (or least automatic) categories of response. Jackson classified utterances, for example, into three levels on this continuum - a) emotional utterances, the most automatic because the words "come out without thinking", b) propositional speech relatively free from emotion and at a mid point between automatic and voluntary, and c) voluntary utterances of the nature of responses to particular commands. The three kinds of utterances occupy different "levels" in neural pathways, the voluntary pathway being the highest and the "emotional" or automatic pathway at a level at which it can keep on functioning undisturbed by the higher level lesions. Levin sees in deliria instances of Jackson's "reduction to a more automatic condition" consequent upon paralysis of the highest cerebral centres.

It is, of course, dangerous to overelaborate an incidental observation and a possible resemblance, but it may well be that in the recovery of consciousness after E.C.T. at a period when the highest centres have been "knocked out" the patient's state is akin to delirium. This Jacksonian view corresponds to the ideas expressed previously, namely that the abolition of higher functions can result in the loss of more mature responses, leaving the less mature intact.

Perception/

Perception

Under this heading are the tests of picture description, identifying objects and right-left discrimination which were included in the battery of questions and tasks in order to indicate to what extent deficits in specific orientations could be due to disturbances of perception, conceptualisation or verbalisation. The tests are crude but were used in preference to more discriminating standardised procedures such as the Bender Motor-Gestalt test because it was necessary to establish a response quickly. While the results of these tests indicate that perceptual processes are not disturbed for the whole recovery period it can hardly be claimed that any complete elucidation of perceptual changes is achieved by these tests. In the picture description test the patient is asked to describe details in a simple picture shown and to express the point of the situation illustrated. Perception in this case is expressed as a verbalised, differentiated and probably more "vulnerable" function than the non-verbal indirect experience which is also perceptual.

Because the possibility had been conceived of a resemblance between E.C.T. recovery and the organic confusional state, an examination of the patient's capacity for right and left discrimination was introduced. This arose because in the literature on perceptual disturbances Juba (1948) discussed/

discussed Wolpert's "Simultanagnosie" as a phenomenon of the immediate post-E.C.T. period. This simultaneous agnosia refers to an inability to perceive the central theme of a picture or action represented in it with the preservation of ability to perceive its details. (Such perceptual distortion was incidentally not revealed in this investigation but its absence may be due entirely to the faults of the investigation of perception.) Juba observed that with this agnosia a Gerstmann syndrome could occur immediately post-E.C.T. This syndrome, Juba states, comprised finger agnosia, right-left disorientation (for the patient's own body, not the examiner's) agraphia and acalculia, and was held to be pathognomic of parieto-occipital dysfunction. This seemed to offer a further basis on which to specify the nature of the post-E.C.T. confusional state, namely in terms of the localisation of the centres involved.

Reference to Gerstmann's original article (1927), however, suggested that Juba had mistakenly used these four symptoms to refer to the syndrome. The essential point made by Gerstmann was that these specific behavioural deficits had to be observed in the absence of more general deficits such as autotopagnosia and alexia. Using the more discrete criteria of the original syndrome it seemed likely that Juba was in fact merely describing a number of changes which occurred after E.C.T./

E.C.T. but which were not necessarily linked as a configuration or syndrome. In this investigation it was decided to examine for finger agnosia and for agraphia if at any time during the recovery period a patient manifested a disturbance of right-left orientation coexisting with acalculia while yet showing no general perceptual disturbance and being able to indicate parts of her body. However, in no case did the hypothesised Gerstmann syndrome appear although disturbed right-left orientation and acalculia were in evidence, but not at a time when the patient was able to respond to the pictures or, for example, to indicate her chin on command.

Conclusion

In this investigation an atomistic or elementaristic attempt was made to examine the process of recovery of consciousness after E.C.T. Within the group studied a pattern of re-emergence of consciousness was noted which was consistent for the group and which indicated in general that personal orientation returned before general orientation. From the developmental viewpoint the basis for personal orientation is acquired at an earlier stage than awareness of other persons or of objects. If this is so then the recovery process accords with Head's statement (p.92) that it begins with the "most preordained responses" and ends with "those of/

of the highest rank". The point at which perceptual ability was restored was not, however, adequately demonstrated.

The basic disturbances demonstrated in the recovery process would seem sufficient to occasion the distress reported by some patients. Gallinek (1956) quotes one of his patients who described the experience of waking up disconnected from the past, in a strange environment, and with feelings of unfamiliarity as "the waking up from nowhere into anywhere". German psychiatrists such as Schildge and Tuebingen (1947) compare the situation of the patient waking up from electro-shock to the situation of Man as described in existential philosophy who finds himself thrown into a world which is not of his own choosing, surrounded by facts which are not of his own making, and is thus afflicted with fear and anxiety.*

Recovery of consciousness from anaesthesia

To investigate the extent to which the pattern of recovery of consciousness noted after E.C.T. is a function of/

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* Footnote. In this respect it is worth while observing that none of the patients observed in this investigation expressed any apprehension about having subsequent treatments (although at a later point in the course one patient's treatment was terminated because of anxiety). This could have been due to the fact that someone was present throughout the whole recovery period, even although he assumed the role of inquisitor rather than sympathetic attendant. The practice in some outpatient E.C.T. clinics of having relatives by the patient's bedside during their recovery would, therefore, seem to be beneficial.

of the convulsion rather than the mere restoration of consciousness, a series of observations was undertaken on patients recovering from the effects of a general anaesthetic.

Although it would have been administratively easiest to have observed patients in the surgical department of the hospital after operation, the prolonged period of anaesthesia induced for this inpatient surgery made the group unsatisfactory for comparison. Anaesthesia for E.N.T. and dental surgery was suitably short in duration but it was felt that patients would be unlikely to communicate easily after dental extractions or tonsillectomy. Accordingly a chance group of 11 patients was observed in casualty department recovering from the effects of anaesthesia induced for minor surgery. This is by no means an adequately designed investigation as the anaesthetic technique varied from patient to patient dependent upon the surgery undertaken and upon the preference of the anaesthetist.

While it may not serve as a control group it does offer a basis for general observations about the recovery process. As before the observations were timed, using the point at which the administration of the anaesthetic ceased as the base line. Questioning was begun once the patients had shown some response to a stimulus such as a finger-snap.

A/

A shorter number of questions was used with these patients but a longer interval was allowed between questions. This was done to prevent a quicker recovery pattern being observed because of the faster rate at which the series of questions was repeated.

Table VII shows the results of this investigation. It will be seen that by contrast to Table VI the recovery of consciousness from the anaesthetic was on the whole characterised by a greater delay in responding to stimulation but that the waking period itself was much shorter than the waking period for E.C.T. The average time for the whole group shows a narrower range of differences and similarly the range of response to individual items is more restricted. The impression gained is that recovery of full awareness from anaesthetics is much more rapid than from E.C.T. and is not characterised by the same confusion and difficulty in orientation.*

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* Footnote. As previously stated the work reported here deliberately excluded observations on patients who were given "modified" E.C.T., mainly because the technique of modifying the convulsion by introducing a relaxant and an anaesthetic drug obscured the recovery period. The expectation that recovery from the modified technique would show a pattern somewhere betwee that for E.C.T. and that for an anaesthetic was borne out from the preliminary interviews. However, the drowsiness after the modified E.C.T. did not permit a continuous examination of the patient's awareness unless a constant sequence of irritating stimuli was presented to keep the patient awake - an unjustifiabl procedure!

TABLE VII

Recovery of Consciousness from Anaesthetics

	Average Time to React (minutes)	Approx. Range (minutes)
Response to examiner	12	6-20
Name	12	6-24
Address	15	8-24
Marital Status	14	10-28
Birth place	15	8-24
Year of birth	16	9-28
Age	20	12-35
Orientation for Place	14	8-18
Orientation for Date	19	14-30
Orientation for Year	19	15-30
Identifying Objects	14	12-18

Jaffe and Bender (1951) on the other hand have been able to demonstrate that during recovery from general anaesthesia a more prolonged perceptual change can occur. They found that in adults there is a loss of the normal ability to discriminate simultaneous stimulation of face and hand which can last for three hours after awakening from the anaesthetic. It must be pointed out, however, that these authors used anaesthetic times of much longer duration than would be comparable with E.C.T.

Again it is interesting to note that their observations are consistent with the previous discussion in that they have demonstrated the disturbance of a response dependent upon some degree of maturation within central nervous systems. The face-hand test shows normally that adults are more likely to indicate stimulation of the face rather than hand whereas children tend to localise stimulation to the hand or even to displace the response to another part of the body. The more mature or adult form of the response seems to be lost immediately after the anaesthetic in favour of the less mature. Once again this is consistent with the Jacksonian notion that interference with and subsequent breakdown of "higher" functions leaves intact or releases "lower" or less mature forms of response.

THE EFFECT OF E.C.T. ON PERCEPTION OF FLICKER

The immediate effect of E.C.T. on psychological processes was described in Investigation IV. In the present investigation a more basic perceptual process will be examined in the period immediately subsequent to the recovery period. This represents a stage at which the patient is apparently in contact with his surroundings and, at least after the first convulsion, is unlikely to report any significant perceptual changes or distortions. However, as will be discussed later, E.C.T. has a significant cumulative effect on psychological processes and it would seem reasonable to expect that in the immediate post-recovery period from a single treatment there would be changes in psychological processes of a fundamental kind such as become manifest during a course of treatments.

In order to examine whether such changes could be elicited it was decided to study a function which was not directly amenable to introspective reporting and which could be tested behaviouristically. From among several possible psychophysiological indicators the patient's capacity to fuse a flickering visual stimulus was selected.

This perceptual capacity was studied by measuring the critical flicker frequency (C.F.F.) which is the threshold for/

for flicker discrimination and represents the lowest frequency at which a flashing light is perceived as steady, or conversely the highest frequency at which such a light is perceived as intermittent.

This phenomenon is an aspect of brightness vision and was originally viewed in physiological terms as being related to the latency period of retinal receptors. Discrimination of flicker has been measured in humans and in animals possessing both rods and cones in the retina; the characteristic curve obtained for flicker discrimination in humans is illustrated from Crozier and Wolf (1941) in Figure 2. This graph indicates that there are two components which can be separated in flicker discrimination - a rod segment and a cone segment. At low intensities of illumination rods seem most active and at high intensities cones seem most active. The C.F.F. is also seen to be dependent upon intensity of illumination, as it varies from two to three cycles per second at very low intensities to above 60 cycles per second at high intensities.

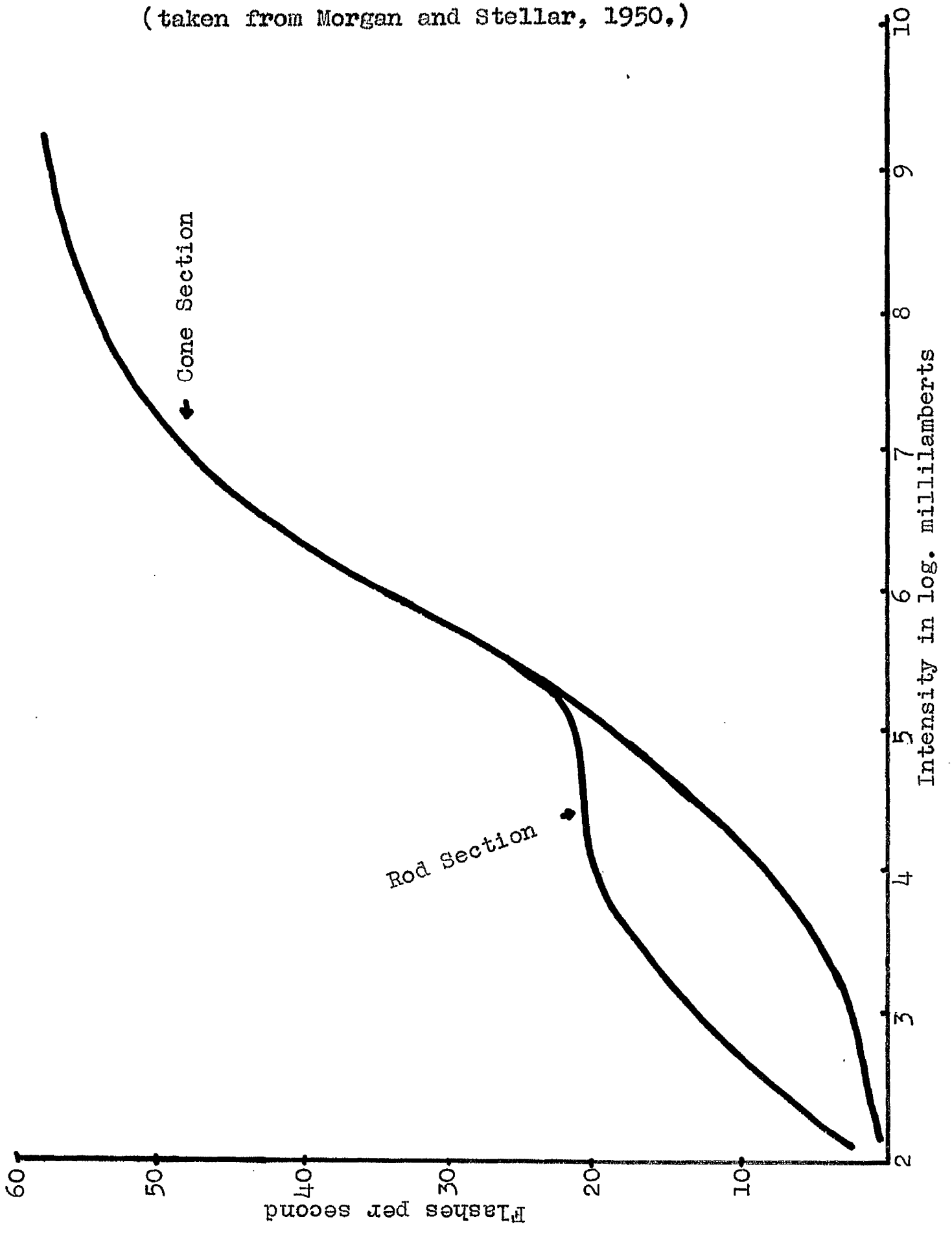
However, measurement of retinal functions alone is not sufficient to give an accurate explanation of the capacity for flicker discrimination. Granit (1947) shows that measurement of retinal potentials during stimulation by a flickering light does not accurately reflect the perception

of/

FIGURE 2

Flicker Discrimination

(taken from Morgan and Stellar, 1950.)



of flicker. The recorded retinal potential shows an initial increase with increased rate of flicker, but at a point in frequency well below the C.F.F. the retinal record shows fusion. This could be due to the fact that the electroretinogram represents an average of mass retinal activity and does not reflect the behaviour of individual units. The alternative interpretation is that C.F.F. is not related to peripheral function but that the determinants of perception of flicker or fusion are in fact central.

This latter explanation appears to be confirmed by the phenomenon of photic driving described by Adrian (see Grey Walter, 1953). In animals, and in man, the alpha or dominant electroencephalographic rhythm can be increased or decreased by raising or lowering the rate of intermittent visual stimulation. This suggests that the electrical activity of visual structures below the cortex is responsible for the perception of flicker (Morgan and Stellar, 1950). There is further evidence of the central character of the fusion mechanism in the observations that there is an individual cyclic variation in the capacity both daily and over weeks, and that metabolic alterations and fatigue states can significantly alter the ability to perceive flicker (Krugman, 1947). More particularly the capacity to perceive flicker has been shown to be reduced in a number of pathological conditions of the central/

central nervous system (Landis et al, 1956).

C.F.F. has been used not only as a measure of central nervous system function but also as a more "psychological" measure. Early studies in perseveration, for example, utilised a measure of C.F.F. in an attempt to devise measures of temperament (Wiersma, 1906). Although this early work did not yield any clear-cut relationship between temperament and C.F.F., Eysenck (1952) more recently postulated that a higher C.F.F. would be found at the extroversion end of his dichotomy rather than at the dysthymic end. A subsequent monograph on perceptual processes and mental illness by Eysenck, Granger and Brengelmann (1957) mentions this prediction but does not report any evidence.

In this investigation, however, it is not intended to consider the C.F.F. as a measure of temperament but as a measure of perceptual processes centrally determined but also dependent upon possible peripheral influences. The relevance of a measure of C.F.F. in assessing changes associated with physical treatment is justified by the finding that, whereas "psychometric" tests of psychological function do not reflect significant changes after psychosurgery, frontally damaged or lobectomised patients show not only a lower C.F.F. than do normal controls but also a lower average deviation over a series of measurements of C.F.F. Halstead (1947) on the basis of/

of such findings asserts that objectively the frontal lobectomised patients are more "accurate" in locating their fusion point on successive trials than are normal individuals although they fuse at relatively lower levels. Accuracy in this sense reflects a reduced flexibility of behaviour rather than increased discrimination.

Investigation V

On the basis of Halstead's work on the effects of psychosurgery, it was decided to use changes in the C.F.F. as a measure of the possible effects of E.C.T. during the immediate post-recovery period. Observations were carried out on a group of 24 female patients who were receiving the first treatment of a course of E.C.T. prescribed for their affective disorder.

To determine the direction and degree of change produced by E.C.T. each patient was used as her own control by obtaining measures of C.F.F. immediately before treatment and after recovery, i.e. at least 40 minutes after E.C.T.

An apparatus was designed to provide a range of flicker frequency capable of being altered throughout its range by the rotation of a calibrated dial. A gas discharge tube was used as the light stimulus. This discharge tube, held electrically at just below its flash potential, was triggered to its operating point by an imposed alternating current whose frequency/

frequency could be altered to give changes in the rate of flashing. The apparatus was designed to give blue-white light at an intensity level which yielded the straight line part of Crozier and Wolf's curve. This was checked by previous random testing on a number of normal subjects and neurosurgical patients, using a series of diffuser screens of differing opacity until it was ensured that the range of C.F.F. responses lay between 22 c.p.s. and 45 c.p.s.

The flicker was presented by having the subject look through an eyepiece which excluded light at a diffuser screen 9" square and at a fixation distance of 18". A control knob on the side of the apparatus altered the rate of flicker. This control knob was positioned in such a way that the subject could operate the knob himself. However, previous trials had shown that when subjects manipulated controls they tended to report several thresholds as they varied the control back and forth through the discrimination point. In this experiment the control was manipulated by the experimenter to allow a uniform direction and rate of change in frequency of flicker. The control was first set at the high end of the scale and each subject was asked to look through the eye-piece and allowed to accommodate for a short while. Then the control was operated and the patient was asked to report when he saw the light flicker or when he saw the light steady.

This/

This threshold was recorded in cycles per second from the calibrated dial.

The method of limits was used by giving a series of trials, generally 10, alternating from below the threshold in increasing steps followed by a trial from above the threshold in decreasing steps. Twenty readings were thus obtained for each patient. These values were simplified by reducing them to the mean ascending and mean descending thresholds for both before and after treatment sessions. These four values are given for the group in Table VIII. To illustrate the origin of this table the raw data for Patient A is given below:-

	Time	A	D	A	D	A	D	A	D	A	D	Thresholds A	Thresholds D
Before E.C.T.	9.23	40	34	35	37	39	32	36	37	33	37	37	36
After E.C.T.	10.12	29	26	35	27	33	32	31	31	30	33	32	30

(A = ascending values. D = descending values)

This is further reduced to the mid point reading which gives a final single score representing the value lying between the ascending and descending thresholds.

Results. Table VIII shows that for this group the mean threshold before E.C.T. occurred at 30.81 c.p.s. and after E.C.T. at 27.47. This difference is found to be significant at/

TABLE VIII

C.F.F. and E.C.T.

	Thresholds (cycles per second)							
	Before E.C.T.				After E.C.T.			
			d	d^2			d^1	d^2
Patient	Ascending values	Descending values	Mid-point value		Ascending values	Descending values	Mid-point value	
A	37	36	36.5	1332.25	32	30	31.0	961.00
B	31	29	30.0	900.00	29	28	29.0	841.00
C	31	29	30.0	900.00	28	28	28.0	784.00
D	31	28	29.5	873.25	24	26	25.0	625.00
E	25	26	25.5	650.25	23	24	23.5	552.25
F	26	24	25.0	625.00	24	24	24.0	576.00
G	31	28	29.5	873.25	25	27	26.0	676.00
H	30	27	28.5	812.25	26	26	26.0	676.00
I	34	32	33.0	1089.00	28	27	27.5	756.25
J	31	30	30.5	930.25	29	27	28.0	784.00
K	34	31	32.5	1056.25	26	24	25.0	625.00
L	37	35	36.0	1296.00	30	28	29.0	841.00
M	37	35	36.0	1296.00	31	31	31.0	961.00
N	32	32	32.0	1024.00	30	29	29.5	870.25
O	34	30	32.0	1024.00	28	24	26.0	676.00
P	36	35	35.5	1260.25	27	25	26.0	676.00
Q	35	31	33.0	1089.00	30	27	28.5	812.25
R	32	27	29.5	873.25	40	32	36.0	1296.00
S	28	26	27.0	729.00	22	22	22.0	484.00
T	31	29	30.0	900.00	26	25	25.5	650.25
U	32	30	31.0	961.00	28	28	28.0	784.00
V	28	25	26.5	705.25	24	26	25.0	625.00
W	29	27	28.0	784.00	29	27	28.0	784.00
X	34	32	33.0	1089.00	32	32	32.0	1024.00
			740	23072.5			659.5	18340.25

Mean pre E.C.T. $\bar{x}_1 = 30.81$ Mean post E.C.T. $\bar{x}_2 = 27.47$

at the 0.001 level (see Appendix E). When the average ranges of readings are compared before and after E.C.T. these are found to be 8.2 and 7.4 respectively, suggesting the direction of Halstead's finding of decreased variability or greater "accuracy". This difference is, however, not significant.

Discussion

These findings suggest that even after one single E.C.T. significant psychophysiological changes can be present at a time when the patient is outwardly fully conscious and apparently able to react to environmental changes.

In the absence of corroborative findings against which the evidence for the reduced C.F.F. can be viewed, it is difficult to postulate the basis for this effect of E.C.T.

Halstead (1947) interprets his finding in psychosurgery patients in terms of his power factor (P). To explain this he uses the analogy of two cars, each of different horsepower. When travelling at a speed of 30 m.p.h. the performance of these cars may be identical; at critical speeds, however, they become differentiated, the car with the lower horsepower failing at a lower absolute speed and within a narrower range of speeds. Similarly, patients after frontal lobectomy fail to resolve flicker at an earlier point and within a narrower range of variation than normals because of a reduction of this power factor in biological intelligence. He does not, however, indicate the nature of the mechanism capable of producing/

producing this reduction, nor indeed the nature of the power factor itself.

Apart from the general question of the validity of the concept of the power factor, Halstead's use of the C.F.F. in this respect can be questioned. Firstly, his figures show that he chose a low intensity of light to give the stimulation for measuring C.F.F. This, however, involves the rod component of the Crozier-Wolf curve as shown above. If this low level of intensity is used it will be seen that frequencies just below 20 cycles per second do not yield as great a variation as do the higher frequencies. Secondly, in his experiment Halstead asked the patient to manipulate the control of the flicker over a wide range of frequencies. This condition may be responsible for some of the differences in variability found between normals and brain damaged subjects who tend to be less able to carry out instructions of this kind with accuracy

Other investigators have found similar C.F.F. changes after E.C.T. Ploog (1955) used 10 healthy controls and 36 psychiatric patients and found that the normal range tended to decrease under the influence of E.C.T. Landis and Clauson (1955) found that their particular methods of measuring flicker fusion threshold were not sensitive enough to reflect any changes which might have been attributable to the effects of E.C.T. This difficulty might have been due to the fact that they did not/

not limit their investigation to the single initial treatment but examined patients before, during and after courses of treatment. In this way the clinical (and in this respect secondary) effects of the E.C.T. in removing depression and retardation could obscure any changes in C.F.F. for which E.C.T. could be held directly responsible.

The possibility of intervening variables such as the peripheral effects discussed earlier must also be borne in mind. Damiani (1956) reports, for example, that after E.C.T. he found in seven of his nine patients an improved light sensitivity, either with respect to luminal values themselves or to the values of the adaptation curve. In all cases the visual fields showed a widening of the peripheral limits. These changes are attributed to oculo-diencephalic mechanisms and the diencephalic stimulating effect of E.C.T.

Finally, the use of the C.F.F. as a measure is deceptive. Because it involves a device whose accuracy can be established one is tempted to regard it as an "objective" measure. In essence, like all psychophysical techniques it depends upon subjectivity or introspective report. The lesson of the experimental work on psychophysics is that in such experiments conditions must be stringent and a large number of precautions have to be taken to avoid errors. Merely getting thresholds is deceptively easy and 10 or more successive readings can be obtained/

obtained which vary very little among themselves, thus adding to the deception. However, as Landis (1956) points out, it is only when one realises "the number of demonstrated determinants of this threshold, the fact of the wide variation in threshold between individual observers, and the fact that even the most experienced and reliable observer will occasionally provide a series of measures quite outside his ordinary performance for which no basis of explanation can be found, and finally the ease with which suggestion, expectation, changes in attitude and the like, may alter any series of measurements; only then can one properly evaluate a change in the level of the flicker fusion threshold which may occur".

COGNITIVE CHANGES AND E.C.T.

In the follow-up study (Investigation I) complaints of memory difficulty were noted among the spontaneous comments of the patients. This disturbance of memory is the most commonly encountered side-effect of E.C.T. and occasions varied reactions among patients experiencing it. To some the disturbance is frustrating or distressing. However, it can be welcomed, as in one patient who in the middle of his course was asked if he was able to remember things satisfactorily and replied that he needed to forget things rather than remember them and that the quicker the electric treatment knocked his memory about the better. In voicing this sentiment he was at least in classical company for when Simonides offered to teach Themistocles the art of memory the latter answered: "Ah! rather teach me the art of forgetting for I often remember what I would not and cannot forget what I would." This patient's assumption that E.C.T.'s purpose is to disturb memory has also been presented as its rationale (e.g. Myerson, 1941).

As in the discussion of fear of E.C.T. it is interesting to note that early workers did not affirm that shock therapy had any effect upon memory. Sherman et al (1941) reported that, in a predominantly schizophrenic group of 10 patients treated either by E.C.T. or by chemical convulsants, no significant/

significant effect on immediate or recent memory was noted. Wittman and Russell (1942) tested 496 patients (of whom 78% were schizophrenics, 6% manic depressive, 9% involutional melancholics, the remaining 7% consisting of psychoneurotics, psychopaths or mental defectives with behaviour disorders) who had been treated by metrazol and insulin, either alone or in combination. They concluded: "Substantiation of the reports of memory defect following therapy has not been found in this study. If such memory defect occurs, it is more than compensated for by the pronounced improvement in interest, attention and social responsiveness on the part of the patient."

Hemphill (1940) found that his patients recognised pictures one hour after metrazol injection which had been presented half an hour before treatment, and thus claimed that no retro-active amnesia was present. Even more recently Brower and Oppenheim (1951) carried out a series of electro-convulsive treatments, and found "very little memory impairment noted at all; if anything, many of the patients showed improved memory scores".

However, each paper claiming to show the absence of ill-effects on memory due to treatment can be matched by one which demonstrates them. Cohen (1939) had found a temporary retrograde amnesia covering a period of a day or more before treatment in metrazol-treated schizophrenic patients. Mayer-Gross (1943)/

(1943) demonstrated retrograde amnesia for about a minute before the electrically induced convulsion. Fleischer (1942) reported cases of permanent retrograde amnesia after treatment among 18 schizophrenic patients treated by E.C.T.

The differences between authors with respect to the presence of memory defects or their nature and degree arises mainly because of the different times subsequent to treatment at which they examined their patients. In general the shorter the period which has elapsed since treatment, the more likely is the defect to be demonstrated. Hetherington (1952) also points out that the early papers tended to confuse their findings by using observations on mixed diagnostic groups of patients receiving different kinds of treatment.

Nowadays the occurrence of memory difficulties is recognised and anticipated by clinicians (see the conclusion to Section I). Kalinowsky and Hoch (1952) have extensively reviewed the literature on memory impairment after E.C.T., drawing an important distinction between those psychological changes which occur after one single shock and those occurring after several shocks or after the course of treatment has been completed.

In Investigation IV the psychological changes due to the single shock were described as disorientation, confusion and resultant loss of familiarity. It is now proposed to deal/

deal with the psychological changes to be noted during the course of treatments which several authors stress as being akin to "organic psychotic reactions" (Kalinowsky and Hoch, 1952; Kral and Durost, 1952). Although these are conventionally described as changes in memory they involve more general cognitive changes.

Investigation VI

To investigate psychological changes occurring during a course of treatments, observations were carried out on a series of patients at pre-treatment intellectual level of at least Grade III on Progressive Matrices, diagnosed as suffering from affective disorder of a depressive type, who had completed a course of at least six treatments by E.C.T. and who were available for follow-up for at least two weeks immediately after the completion of this course of treatment. Eventually records for 18 such patients were obtained. This group was composed of 10 female and eight male patients with the following basic data:-

Pt.	Sex	Age	P-M Grade	No. of E.C.T.	Response to treatment
A	F	43	III+	8	Recovered
B	F	37	III	10	Recovered
C	F	51	II	6	Improved
D	F	51	III	8	Recovered
E	F	32	III+	11	Recovered
F	F	48	III+	6	Improved
G/					

G	F	36	II	7	Unchanged
H	F	58	II	12	Recovered
I	F	49	III+	8	Recovered
J	F	47	III	6	Recovered
K	M	50	III+	12	Improved
L	M	38	II	9	Recovered
M	M	44	II	6	Improved
N	M	57	III+	11	Improved
O	M	49	III	12	Recovered
P	M	47	III	8	Unchanged
Q	M	35	II	7	Recovered
R	M	45	III+	8	Recovered

* Response to treatment assessed at an interval of only two weeks after completion of course.

The average age for the whole group was 45.3 years (45.2 for females, 45.6 for males) and the average number of E.C.T. was 8.7. Eleven out of the 18 were considered to have recovered from their illness, five to have shown some degree of improvement and two to have shown no response.

The following tests were used:-

a) Progressive Matrices.

b) Learning of paired associates.

c) Recall-recognition of previously learned material.

d) Sentence recognition.

e) Orientation for Time, Place, Circumstances, Person.

This battery of tests was administered over a series

of/

of interview sessions, Session I being at least 24 hours before the first treatment, Session II at 24 hours after the third treatment and subsequent sessions being at weekly intervals during the course of treatment (i.e. at least 24 hours after alternate treatments in a twice weekly regime) and at weekly intervals after treatment had been completed.

This method of serial testing allowed the convention to be followed of using each patient as his own control. The purpose of the investigation was explained to each patient as being a way of finding what effect the treatment was having on him and his co-operation was requested. While some of the patients were understandably perplexed about the nature of the tests, none withheld his co-operation. At the interviews, apart from the formal testing, patients talked about their illness, the circumstances of their stay in hospital, home-life, interests, etc.

Description of Tests and Results

a) Progressive Matrices. The 1938 form of this test was administered individually at each interview. Testing was untimed and to reduce possible boredom at all sessions subsequent to the first the number of test items was reduced by using alternate designs in sections A, B, C, and D but all the designs in section E. This split the test in effect into two parts which were applied alternately. Such a procedure

was/

was justified because of the progressive nature of each test confirmed from the item-analysis (Raven, 1947), and its reliability was checked by an ad hoc application of these alternate halves of the test to a group of trainee nurses whose scores on the full test were available. The test was included in this battery as a standardised measure of intelligence and was intended to reflect the baseline against which other cognitive changes could be appraised. It is inaccurate, however, to claim that this is a measure of general intelligence as the Mill-Hill Vocabulary scale was not included in this battery.

Table IX shows the raw scores for the 18 patients at sequence of sessions. Session I relates to the pre-treatment scores and subsequent sessions to scores during the course of treatment. The circled numbers are scores at sessions subsequent to the completion of the course of treatment. In order to display the trends within the group during these sessions the raw scores are averaged for each patient and in Table X the deviations from this average for each individual are given for the pre-treatment, treatment and post-treatment sessions. The average deviations for the group when presented as a graph (Figure 3) show a sharp decline after the first treatment with a gradual rise to a post-treatment level corresponding to the pre-treatment score. The secondary dip

which/

TABLE IX

Matrices Raw Scores

	Sessions								
	I	II	III	IV	V	VI	VII	VIII	IX
A	40	31	34	35	29	(42)	(41)	(43)	(43)
B	39	34	34	37	32	39	(39)	(39)	
C	44	40	41	41	(40)	(43)			
D	33	33	32	33	35	(35)	(35)		
E	45	41	43	45	43	42	42	(47)	(46)
F	37	35	31	31	(34)	(35)			
G	47	44	-	40	41	(44)	(42)		
H	38	32	31	33	39	38	35	(36)	(36)
I	39	38	35	35	32	(37)	(37)		
J	34	26	29	31	(32)	(30)			
K	36	30	36	34	29	27	35	(35)	(38)
L	50	44	48	51	51	50	(46)	(46)	
M	46	40	41	-	(40)	(43)	(47)		
N	29	27	27	30	33	35	35	(35)	(35)
O	33	30	31	35	-	33	33	(33)	(33)
P	34	33	35	33	32	(35)	(34)		
Q	47	47	48	47	49	(48)	(49)		
R	40	38	42	45	-	(45)	(45)		

TABLE X

Matrices Scores

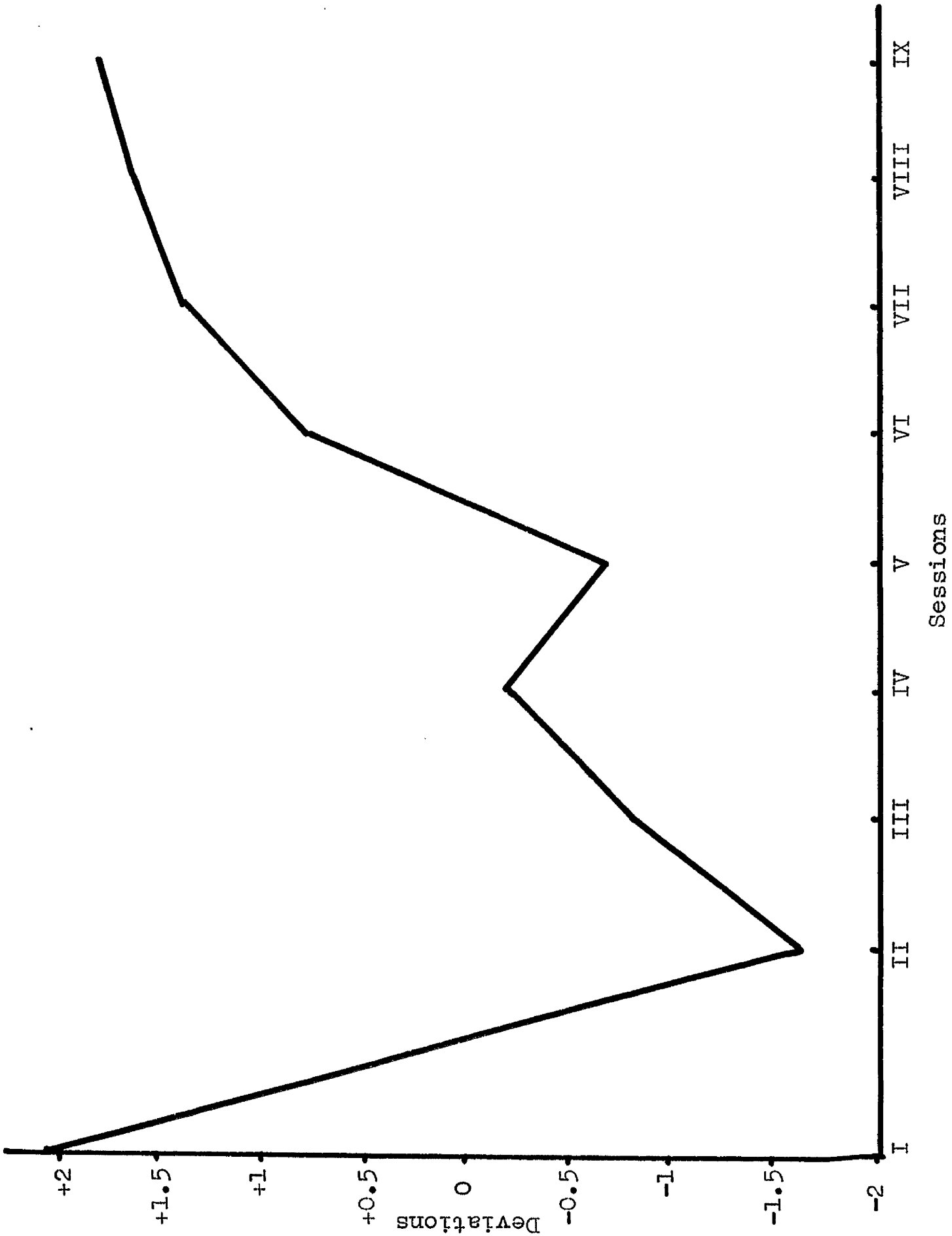
Deviations from Average Calculated from Table IX

Pt.	Average	Deviations										
		1 I	2	3	4	5	6	7	8	9		
					During Treatment				After Treatment			
A	34	+6	-3	0	+1	-5			+8	+7	+9	+9
B	36	+3	-2	-2	+1	-4	+3		+3	+3		
C	42	+2	+2	-1	-1				-2	+1		
D	33	0	0	-1	0	+2			+2	+2		
E	43	+2	-2	0	+2	0	-1	-1	+4	+3		
F	34	+3	+1	-3	-3				0	+1		
G	43	+4	+1	-	-3	-2			+1	-1		
H	35	+3	-3	-4	-2	+4	+3	0	+1	+1		
I	36	+3	+2	-1	-1	-4			+1	+1		
J	30	+4	-4	-1	+1	-			+2	0		
K	32	+4	-2	+4	+2	-3	-5	+3	+3	+6		
L	49	+1	-5	-1	+2	+2	+1		-3	-3		
M	42	+4	-2	-1					-2	+1	+5	
N	31	-2	-4	-4	-1	+2	+4	+4	+4	+4		
O	32	+1	-2	-1	+3		+1	+1	+1	+1		
P	33	+1	0	+2	0	-1			+2	+1		
Q	48	-1	-1	0	-1	+1			0	+1		
R	41	-1	-3	+1	+4				+4	+4		
Totals		+37	-31	-13	+4	-8	+6	+7	+29	+33		
Average Deviations		+2.1	-1.7	-0.8	-0.2	-0.7	+0.9	+1.4	+1.6	+1.8		

FIGURE 3

Matrices Scores

Average Deviations (see Table X)



which appears at Session V may possibly be an artefact due to the numbers of patients finishing treatment at this time whose preceding improvement in performance was due to a quicker rate of clinical improvement. On the other hand this biphasic characteristic of the curve is also found in Michael's results which are discussed later (p.158).

In Appendix F the difference between the results on Session I and on Session II is found to be highly significant, and between Session I and the first post-treatment session to be not significant. Further, within the treatment sessions the rise from the first two scores (i.e. Session II and III) to the last two (Sessions VI and VII) is found to be significant.

It appears from this that during a course of E.C.T. there is a decrease in scores on cognitive tests following the first three treatments and thereafter a return of performance until the pre-treatment level is reached before the end of the treatments.

b) Learning of paired associates. This is a conventional laboratory technique which allows the individual's process of learning to be scored. The subject is presented with the task of learning a series of pairs of words, analogous to the "real-life" situation of learning what a word in one language stands for in another. In this test the criterion of two successive/

successive correct responses to the stimulus word was taken as indicative of learning. The score was the number of trials necessary to achieve this criterion for each list of five words. Two kinds of response words were used, a) meaningful, consisting of a word of similar length to the stimulus word but not offering a manifest association, and b) nonsense words, compounded from "made-up" disyllables such as are used in the classical Ebbinghaus' experiments (Hilgard, 1951). Such nonsense syllables are recognised as having an associative value and are thus not properly meaningless stimuli. The lists used in this experiment are as follows:-

List A	Table	- Wish	List A_1	Leather	- Kupod
	Rather	- Brush		Carpet	- Gokem
	First	- Mind		Towel	- Babab
	Many	- Order		Steel	- Latuk
	Pair	- Worn		Wheat	- Defig
List B	Ache	- Four	List B_1	Pottery	- Runil
	Fit	- Begin		Felt	- Polef
	Just	- Danger		Glass	- Medon
	Party	- Trace		Cotton	- Firum
	Term	- Ought		Paint	- Lactil

List C/

List C	Proceed - Broad	List C_1	Twine - Ridas
	Laugh - String		Board - Delit
	Single - From		Pencil - Lumag
	Need - Over		Gravel - Tarop
	Item - High		Nails - Calan.

These words were typed on separate cards, the stimulus member of the pair being on one side and the response member on the other. Each card was presented to the subject and he was asked to read the stimulus word. The card was immediately reversed and he was asked to read the response word. The card was then discarded and the next card presented until all five cards in the list had been read. The cards were then represented and the subject asked to give the response word before the card was turned over. If he could not do so the card was then turned over and he repeated the response word. Whenever he was able to anticipate the response word correctly on two consecutive trials the card was discarded and the examination continued with the remaining cards until the subject had correctly anticipated all the response words. The total number of presentations after the first reading of the cards was taken as the learning score. The arbitrary limit of 55 trials, i.e. an average of 11 presentations per pair of associates was taken and beyond this point no learning of the list was held to have occurred.

The/

The arrangements for testing were as follows:-

Session I (pre-treatment) - List A and List A_1 learned.

Session II - List B and List B_1 learned.

Session III - List C and List C_1 learned.

First post-treatment session - List A learned.

Second post-treatment session - List B learned.

The design of the experiment could have permitted relearning of each of the lists during the treatment sessions. This was not undertaken as the same material was used to test recall and recognition and thus rehearsal effects were avoided. During the treatment sessions both meaningful and semi-meaningful lists were used but in the post-treatment tests only meaningful material was used as the trend of scores in the semi-meaningful tests was seen to follow that of the meaningful.

Table XI shows the results for each patient at each session. From each individual's average score a table of deviations is prepared (see Appendix F). The average deviation for the group at each session is graphed in Figure 4 to show that the number of trials necessary to learn a list of paired associates increases after E.C.T. has been started, and is still relatively high for the two weeks after the end of the course of treatments. The differences between the points on this graph are found to be significant (see Appendix F).

This/

TABLE XI

Learning Paired Associates

Patient	Pre-treatment		Treatment				Individual Average	Post-Treatment		Individual Average
	List A I*	List A1 I	List B II	List B1 II	List C III	List C1 III	A1 B1 C1	List A I	List B II	ABC
A	15	37	17	55	55	55	49	43	24	29
B	40	35	28	38	46	50	31	41	35	38
C	22	34	18	40	20	55	43	29	12	20
D	24	24	22	-	34	48	36	36	19	27
E	16	19	18	50	25	-	35	21	18	20
F	32	38	30	42	46	55	45	50	24	36
G	23	27	26	44	42	50	40	28	32	30
H	21	24	15	28	26	29	27	20	24	21
I	18	-	17	26	21	55	40	17	22	19
J	27	29	20	26	29	37	31	32	19	25
K	29	33	24	-	24	44	39	35	18	26
L	21	28	27	29	48	55	37	46	19	32
M	16	18	12	38	26	35	30	18	18	18
N	33	32	35	47	35	55	45	30	27	34
O	12	15	15	-	40	42	29	28	17	22
P	35	38	37	49	-	55	47	40	32	36
Q	19	27	19	29	45	55	37	34	22	28
R	13	-	13	25	17	38	32	16	13	14
Totals	416	458	393	566	579	813		564	415	
N	18	16	18	15	17	17		18	18	
Averages	23.1	28.6	21.8	36.4	34.1	47.8		31.3	23.1	

This suggests that ability to learn new material is significantly affected by E.C.T. and that such a difficulty is beginning to resolve but is still present two weeks after the treatment.

c) and d) Recall and Recognition. Testing of recall was carried out by extending the learning situation in time. Patients were presented with the cards containing the list of paired associates learned at the previous testing session. As before they were shown the stimulus-word and asked to say what word was on the back of the card. However, if they were unable to give the correct response the card was not turned over, but another stimulus word presented. The number of words properly anticipated constitutes the recall score, the maximum, of course, being five in each of the two lists presented.

Recognition demands that the subject is able to indicate what is most familiar in a situation. The response words which the patient was unable to anticipate in the recall test were each presented in a group of four words of similar size, position varied at random within the group, and the patient was asked to indicate which of the four words was the response word or to choose which word seemed most likely to be associated with the stimulus word. The score is the number of response words correctly recognised plus the number of words previously/

previously recalled.

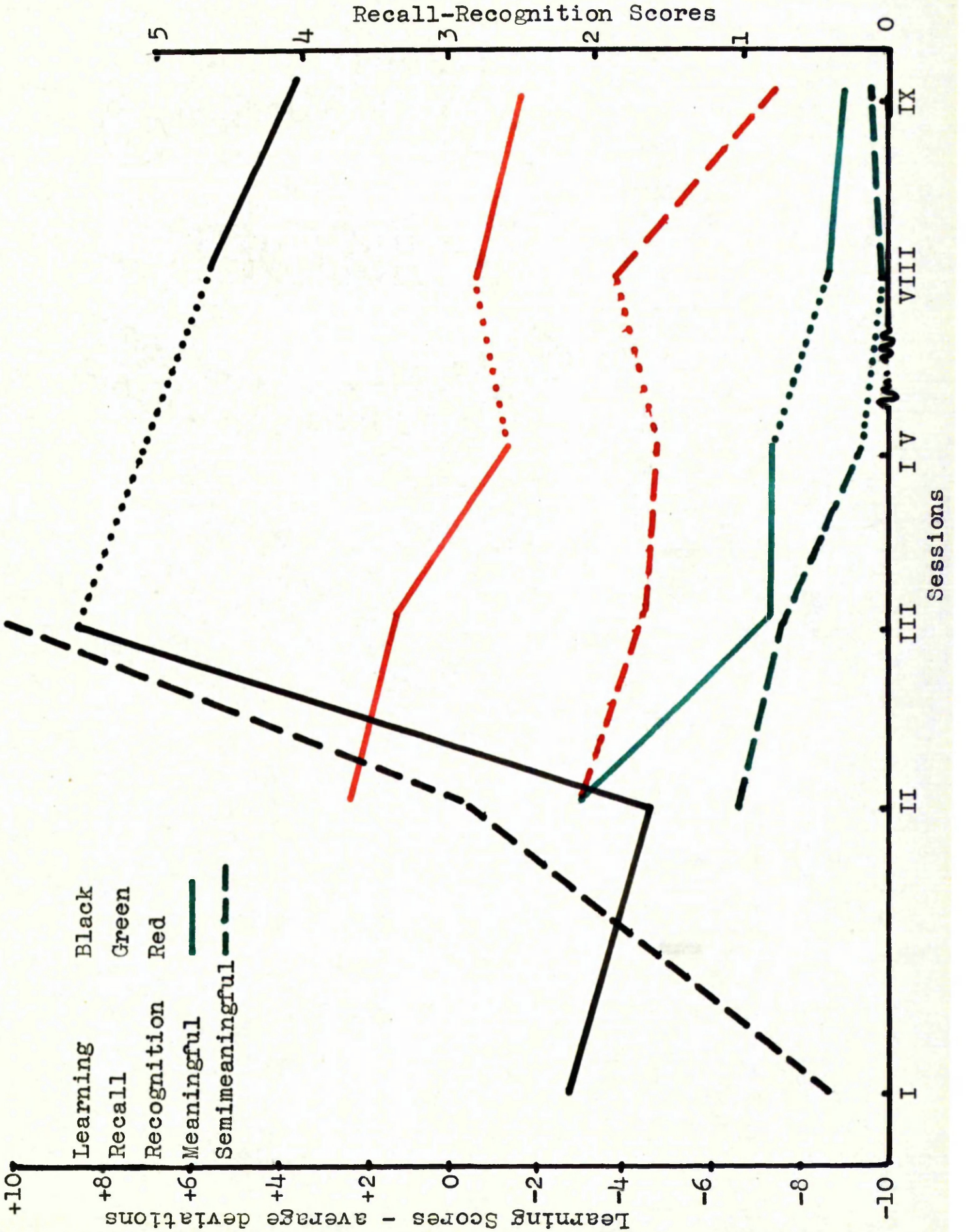
A qualitative test of recognition was used by asking the patient to look at a number of sentences each typed separately on cards, one of which had occurred in a newspaper item which had been read at the first interview. At this initial interview the patient had been shown the paragraph and had been asked to discuss its content in order to confirm that it had been comprehended. At interviews after treatment had begun he was asked to select the sentence which seemed familiar and then asked if he could reproduce the context in which this sentence had appeared. This was not scored but note was taken of how well the patient could describe the original passage once he had recognised the sentence.

The results of these tests are given as averages for the group only. This is done to avoid the fallacy of drawing statistical inferences from individual variances and assuming that these reflect a change in the patient's memory during treatment. The design of this experiment is not sufficient to demonstrate such changes in ability and was intended merely to reflect the difference between recognition and recall. In this case testing was carried out in Sessions II, III and IV during treatment and in the post-treatment sessions.

(i)/

FIGURE 4

Learning, Recall, Recognition Scores.



(i) Using meaninfgul material

	Treatment			Post-treatment	
Sessions	II	III	IV	I	II
Av. Score-Recall	2.1	0.8	0.8	0.4	0.3
Av. Score-Recognition	3.7	3.4	2.6	2.8	2.5

(ii) Using semi-meaningful material

	Treatment			Post-treatment	
Sessions	II	III	IV	I	II
Av. Score-Recall	1.1	0.7	0.2	0	0.1
Av. Score-Recognition	2.1	1.7	1.6	1.9	0.7

These results indicate that, although recall of previously learned material appears to be faulty, recognition is relatively intact at each session. This is particularly so in the post-treatment sessions which represent an interval between learning and recognition of at least two weeks' duration (See Figure 4).

Similarly, intact recognition was noted when the patient's recollections of the isolated sentence were considered. Many patients were able to reproduce the context in which this sentence had occurred. However, several did not appear to recollect the total situation in which this sentence had been encountered, saying for example that they knew what it was about/

about and that they must have read it in some newspaper or other at some time. These patients when asked to state how long ago they had read this sentence were usually unable to locate such an event in time. This phenomenon is also encountered in the examination for disorientation.

e) Orientation. At each interview patients were examined for orientation for person (name, age, address, marital status), for time (day, month, year), for place and for present circumstances (details of illness etc.). The numbers of patients in the group who showed themselves to be fully oriented in each of these categories is shown below for each session.

	Pre-treatment	Treatment						Post-treatment		
Session		II	III	IV	V	VI	VII	I	II	III
Numbers examined	18	18	17	16	12	6	5	18	18	2
Person	18	16	14	13	8	4	2	10	12	0
Time	12	8	4	3	2	0	1	6	6	0
Place	17	16	14	15	12	6	5	18	18	2
Circumstances	17	18	17	15	12	6	5	18	18	2

These figures suggest that, whereas orientation for place and circumstances is maintained during treatment by E.C.T., personal and temporal disorientation tends to occur within the group as treatment progresses. In particular a disorientation for age occurred in personal data (as discussed

in/

in investigation IV). The most frequently encountered temporal disorientation was with respect to ability to localise a particular event in time with a tendency to lengthen the estimated time lapse. For example, the patient might recall an interview that had occurred the previous day but state on questioning that it had taken place "at least a week ago".

In conversation during their course of treatment patients would exhibit their confusion by giving information about themselves as if for the first time, although they had previously imparted the information. One patient, for example, on three occasions related that she had been asked to serve on a club committee, each time insisting that she return to the ward to bring the letter to show the examiner.

Changes in intellectual level with E.C.T.

Brower and Oppenheim (1951) used the Wechsler-Bellvue Scale on 50 cases of depressive disorders treated by E.C.T. One week after the end of treatment their results showed a slight average increase in I.Q. over the pre-treatment level. Analysis of the Wechsler subtests showed that the increase in I.Q. was due to increase in performance scores, viz. Block Designs, Similarities, Picture Completion, and that the other tests showed no significant increase. Brooks (1948) had previously found this increase in Wechsler performance I.Q. in a group of patients treated with combined insulin and E.C.T. but/

but had claimed that such an improvement in scores was related to clinical improvement. It should, of course, be pointed out that the interpretation of spurious relationship between clinical recovery and improved test score can only be cautiously offered. Among the factors which have to be borne in mind are the differential extent to which pre-treatment test scores are depressed by factors in illness itself, practice effect and the relationship between intellectual level and prognosis with E.C.T.

Stone (1947) claimed to have demonstrated a significant decline in intelligence test scores from the beginning to the end of treatments with a significant rise in the post-shock period. However, the tests used in his investigation were subtests of the Army Alpha Scale which yielded a high correlation with the Wechsler Memory Scale suggesting that these changes were predominantly in memory and not in general cognitive ability. However, in 1950 he quoted two cases with psychometric assessments which had been carried out before the onset of illness and in whom E.C.T. produced no alteration in test scores.

Scherer (1951) related pre-treatment scores on psychometric tests to prognosis and found that patients, who were more responsive to their environment and who could think creatively and accurately but who nevertheless showed motor retardation, had a better chance of improvement.

Rubin/

Rubin (1954) reported that verbal and perceptual skills were adversely affected by E.C.T. though motor skills were not, and that these changes still persisted two weeks after the end of treatment. Wilcox (1954), however, found that the decrement in intellectual functioning was fully resolved two weeks after E.C.T. The difference in the results claimed by these two workers is possibly due to the differences in the number of treatments given to the groups of patients they observed. In Rubin's group approximately 20 E.C.T. were given and in Wilcox's group 10 E.C.T. constituted the average course.

Hetherington (1952) found with depressive patients that E.C.T. produced two effects working in opposite directions, namely a decrease in the rate of "accurate mental work" and a simultaneous increase in the rate of motor response.

The literature on the effects of E.C.T. on intellectual functioning thus presents a number of discordant findings. Differences between investigators exist with respect to experimental technique, the diagnostic status of the group studied, the intervals chosen between investigations, the types of test used, the number of treatments given and the spacing of treatment.

The investigation reported here has certain advantages. It offers observations on a diagnostically homogeneous group of patients in whom no intellectual deficit had been observed before/

before treatment nor in whom, because of the age range, was any such deficit expected; the number of treatments in the group varied only within the usual range of prescription, and the testing sessions were separated at a standard interval long enough to prevent the immediate effects of the single treatment being reflected.

Discussion

It seems that the loss of cognitive function with E.C.T. represents a temporary suspension rather than a deletion. The initial loss of cognitive functioning and its subsequent restoration to a level at or above the pre-shock level is confirmed by other workers using different indicators of cognitive change. Callagan (1952) used a battery of cognitive tests to assess the effects of E.C.T. on test performances of hospitalised depressed patients. The hypothesis that as a result of E.C.T. scores on such tests would tend towards the "normal" end of Eysenck's "normal-psychotic continuum" was confirmed when changes were assessed after the fifth week. However, in the first week the cognitive changes were found to be contrary to this prediction, particularly in regard to such functions as expressive movements, mental fluency and manual dexterity.

Michael (1954) used the Stanford-Binet word-meaning test to examine impairment of mental functioning in patients under treatment/

treatment by E.C.T. Half an hour before each treatment subjects were asked to name as many words as they could in a period of three minutes, keeping their eyes closed in order to eliminate visual clues. His results showed that after an initial increase in average word score there was a decrease which was reversed after the sixth treatment. Subsequent to this restoration there was a secondary decrease in performance and a rebound to pre-treatment level within a week of completing the course. The biphasic nature of the curve of this detriment (see Figure 3), previously interpreted as being due to differential rates of improvement of patients within the group, is confirmed by Michael's work and may possibly have more fundamental implications.

It is possible to interpret this secondary rise and fall in accordance with previously expressed Jacksonian concepts. The functions upon which an individual's performance on Matrices and word-naming tests depend are not unitary but involve several factors each of which corresponds to a different functional level. The biphasic shape of the curve can thus be attributed to the differential effects of E.C.T. upon such factors, the secondary fall and rise resulting from a reduction of a "higher" function and the consequent assertion of a "lower" level function which determines performance on the test.

Changes in learning capacity with treatment are seen to show/

show an initial improvement followed by a loss of capacity which is still present two weeks after treatment. This suggests that E.C.T. produces a loss of capacity to assimilate new material. The recognition tests on the other hand show that some assimilation has occurred, although the material cannot be recalled with ease. Many authors such as Zubin and Barrera (1941), Williams (1950), Worchel and Narcisco (1950) have suggested that the memory impairment caused by E.C.T. is due to the inaccessibility of memory-traces rather than to their loss or to the patient's inability to assimilate.

The particular disorientation for time which was observed confirms this idea of the inaccessibility of memory-traces. The patient demonstrates that particular events have registered with him but their total recall in context is hampered. Here there is a similarity to the cognitive changes in organic brain disease which also indicate defective accessibility of previously assimilated material.

In presenile dementia, for example, the patient shows a disorder of immediate memory as an early sign of the disease. This circumscribed disorder occurs in the absence of significant alterations of consciousness and the pathological changes are confined to the cortex and are either diffuse or localised to the frontal area. In other organic conditions, such as the Korsakow state previously discussed when the memory defect is associated/

associated with alterations of consciousness, the pathology appears to affect lower and mid-brain centres. It would thus seem that accessibility of memories depends not only upon intactness of cortex but also of subcortical structures.

Penfield (1951) suggests that a centrencephalic system is involved in memory processes. By direct stimulation of the temporal cortex at neurosurgical operations he was able to evoke in his patients recollections of previous experiences which, however, were not projected into past context but were reported as being like present experiences. The fact that this effect occurs bilaterally leads Penfield to locate the underlying mechanism in the upper brain stem because, he argues, only at this level would it be possible to have an integrating system connected with both hemispheres and capable of projecting bilaterally to the temporal cortex.

SUMMARY OF SECTION II

1. A study of the effectiveness of E.C.T. by follow-up of a diagnostically mixed group of patients indicates that this treatment is specific for depressive illness. This finding is the basis for the subsequent use of homogeneous groups of patients, diagnosed as suffering from depression of affect, in other investigations.

2. This follow-up study also suggests that fear of treatment may be related to clinical improvement. Further investigation of this relationship, however, shows that fear of treatment is independent of the response to treatment, and it is suggested that fear or anxiety may be occasioned in the treatment situation by the recovery of consciousness.

3. Examination of certain variables in the convulsive reaction shows a relationship between pre-treatment tension and latency which is taken to denote the significance of the convulsive threshold.

4. The concept of anxiety is then discussed with particular reference to its "warning" or "alerting" functions, and some evidence is offered of the role of subcortical structures in particular the reticular activating system.

5. A study of the process of recovery of consciousness shows disorientative features which are discussed in terms of Jackson's/

Jackson's hierarchical concepts indicating that the abolition of "higher functions" by E.C.T. is accompanied by a release of "lower functions", again compatible with the view that E.C.T. acts at subcortical levels.

6. In the post-recovery period from the first treatment the persistence of such subcortical changes is demonstrated by investigating changes in the perception of flicker. These changes occur even although the patient is held to have recovered consciousness.

7. The cumulative effects of treatment on cognitive functions are examined during a course of treatment. The fact that performance on cognitive tests, after being initially reduced, returns to pre-treatment level before the end of the course suggests that adaptation occurs with repeated treatments. The ability to assimilate new material is lowered but not abolished, and the accessibility of this assimilated material is reduced. Again brain systems below the cortex seem to be involved.

The evidence suggests that E.C.T. acts primarily at a lower level of brain function than is consistent with conventional views of the determinants of consciousness. The next section will, therefore, be devoted to relating these findings to recent views on the neural determinants of consciousness.

S E C T I O N III

Conclusions and Discussion

CONSCIOUSNESS.

Most of the difficulties concerning the term consciousness have arisen from its apparent introspectionist origins. If introspectionism is its source then our notion of conscious has been fostered in dualistic dichotomies originating in the ideas of Descartes and reaching fixity with the British empiricists. Descartes' "cogito,ergo sum" made consciousness the basic and undeniable reality of one's own existence. Locke, Berkeley, Hume, Hartley, Reid, Stewart, Thomas Brown, Mills and Bain were all concerned with how mind gets to know the external world starting from a fundamental mind or matter dichotomy.

William James in his Principles (1890) makes the introspectionist approach a dogma when he states:- "Introspective observation is what we have to rely on first and foremost and always. The word introspection needs hardly to be defined - it means, of course, looking into our own minds and reporting what we there discover. Everyone agrees that we there discover states of consciousness. So far as I know, the existence of such states has never been doubted by any critic, however sceptical in other respects he may have been. That we have cogitations of some sort is the inconcussum in a world most of whose other facts have at some time tottered in the breath of/

of philosophical doubt. All people unhesitatingly believe that they feel themselves thinking and that they distinguish the mental state as inward activity or passion from all the objects with which it may cognitively deal. I regard this belief as the most fundamental of all the postulates of Psychology and shall discard all curious enquiries about its certainty as too metaphysical for the scope of this book." In spite of James' enviable certainty, developments in psychology since his day seem to have stemmed from various forms of doubt about this very inconcussum.

The philosopher can start from a description of consciousness as the distinctive character of whatever may be called mental life. It is the point of division between mind and not mind. In the absence of mind there is total unconsciousness in the sense attributed to a piece of wood. Whenever there is mind in some form we denote it by the word consciousness. To the earlier English psychologists the word signified the mind's direct cognisance of its own states and processes. Thus, Locke:- "Consciousness is the perception of what passes in a man's own mind", and Reid:- "Consciousness is that immediate knowledge which we have of all the present operations of our mind". Metaphysicians such as A.E. Taylor have, of course, always been concerned to point out the subjectivist fallacy - "We cannot too strongly insist/

insist that, if by selfconsciousness is meant a cognitive state which is its own object, there is no such thing, and it is a psychological impossibility that there should be any such thing as selfconsciousness. No cognitive state ever has itself for its own object. Every cognitive state has for its object something other than itself." (Baldwin, 1925).

The philosopher's difficulty seems to lie in the fallacy of misplaced concreteness. We have available to us in our experience certain processes or operations, all of which have a common character; we abstract this common character and call it consciousness and then call the processes "states" or "modifications" of this abstraction, just as in dealing with things we start from an abstraction of their common property which we term"matter" and then talk as if the things themselves were forms of matter.

The associationist school of philosophy has tended to widen the original introspectionist use of the term consciousness. Bertrand Russell (Analysis of Mind, 1921, p.40) argues that, since man has developed out of the animals and since there is no serious gap between him and the amoeba, something closely analogous to knowledge and desire as regards its effect on behaviour exists among animals, even where what we usually call consciousness is not attributed. "It is, therefore natural to suppose that whatever may be the correct definition of/

of consciousness, consciousness is not the essence of life or mind." In his "Outline of Philosophy" he describes consciousness and its operation in the processes of perceiving, describing both physical processes external to the body, then processes in the eye, nerves and brain, producing finally a pattern which, by the law of association, gives rise to tactual and other expectations and images, as well as memories and other habits. "But everything in this whole series consists of causally continuous change of events in space-time, and we have no reason to assert that the events in us are so very different from the events outside us - as to this, we must remain ignorant since the outside events are only known as to their abstract mathematical characteristics, which do not show whether these events are like thoughts or unlike them." This disposes of the mind-matter dichotomy and allows Russell to state the practical function of consciousness and thought to be "that they enable us to act with reference to what is distant in time or space, even though it is not at present stimulating our senses." ("Analysis of Mind").

The philosophers' process of hardening themselves against the ghostly notion of mind has been carried furthest by Ryle (1949) who rejects the notion of consciousness or of a mind as an entity of some sort, just as brain, a hand or a nose is an entity. Originally mind was thought of as a queer mysterious entity/

entity as indicated by the queer, mysterious names which have been used to replace it, such as soul, ego and psyche. Ryle argues that mind is neither mysterious nor an entity and that, as before, its mystery arises from our tendency to treat an abstraction as though it were concrete. Ryle's treatment of the problem can be summarised in the following simple example. We know that if we bend a piece of wood sufficiently hard it will break. We can, therefore, say of this piece of wood that it has a tendency to break. Saying that the wood has a tendency to break is not like saying that a man has a brain, a hand or a nose, for there is no such entity as a "tendency to break". To say that the piece of wood has a tendency to break is merely to state that if certain conditions are fulfilled then it is likely that the wood will break. Ryle suggests that to say that a person has a mind is similar to saying that the wood has a tendency to break. Thus the mind or consciousness is not to be thought of as an entity but as a complex of dispositions. To say that a person has a mind, therefore, does not mean that in addition to his body there is a ghostly something, i.e. his mind, known only to himself and to others by hearsay only. It means that his body has a complex set of dispositions to behave in various ways. Ryle concludes: "The mind is not the topic of sets of untestable, categorical propositions but the topic of sets of testable, hypothetical and semi-hypothetical propositions."

This/

This sort of argument seems psychologically acceptable and can take us out of philosophy. The psychological version of Ryle's statement is that we know about the mental capacities of an organism by knowing about the properties of the organism. This, however, immediately raises the question of what properties an organism must have to make it appear with any reasonable degree of certainty to be a conscious human being. Psychologists have tended to avoid the issues involved in such a question, particularly when its answer depended upon recognition of bodily dispositions, as above. For example, B.F. Skinner (1938) in his operationist approach deals with the properties of the empty organism and intentionally ignores the nervous system and all hypotheses, speculation and intervening variables. To Skinner the properties of the organism are simply the ways in which stimulation and response are connected, just as the properties of any electronic instrument are the ways in which the electric output is related to the electric input. However attractive this simple solution may be, Skinner still uses the process of introspection as a psychological property of living human organisms. We are thus brought back to the previously mentioned difficulties of the confusion of consciousness meaning awareness of environment and consciousness meaning awareness of mental processes themselves.

Cobb (1952) on the other hand, ignoring these difficulties and using the term to mean both awareness of environment and

of/

of self, holds that consciousness is something more than just a response to stimulation, for a response can occur at spinal levels at which no awareness is involved. If we follow Cobb's argument then he will introduce us to the neural implications of the bodily dispositions which Ryle attaches to "mind" for he asserts right away that consciousness is a property of the organism in action just as much as contraction is a property of muscle. It is a physiological function and as such is associated with a system of organs, specifically the central nervous system. The central nervous system represents a hierarchy of more and more complex neural mechanisms and consciousness is integrated at manylevels, dependent upon the existence of reverberating circuits between cortex and thalamus and relationships between cord, brain stem, hypothalamus, thalamus and cortex. The core of Cobb's argument can be stated in three propositions which he holds to be valid for the contemporary state of knowledge:-

a) No biological process occurs without involving a change in structure.

b) Whenever the brain functions there is organic change.

c) The brain is the organ of mind.

We have reached a point at which we have apparently resolved many of the philosopher's problems by an assertion that psychological phenomena such as thinking, knowing, willing/

willing, are just as much functions of the organism as are walking, excreting, digesting, for there are no other kinds of function, unless supernatural. This may not be an entirely satisfactory position to maintain but it serves to translate the problem into the clinician's field which deals with phenomena related to illness and disease processes.

It might be expected that the neurologist's views on consciousness would arise from an entirely different set of determinants from those of the philosopher. This may not be entirely so, for Riese (1954) claims that Cartesianism and Evolutionism were the two greatest influences in the development of the views of Hughlings Jackson and thus in the development of contemporary neurology. The significance of evolutionary thought seems obvious enough in Jackson's concept of hierarchy and the Cartesian philosophy may have determined his acceptance of a mind-body dichotomy as exemplified in his often quoted remark: "There is no physiology of the mind any more than there is a psychology of the nervous system." Certainly, although from different premises, he arrives at statements which have the characteristic Cartesian stamp of separating subject and object. For example, although the highest cerebral centres were to Jackson the physical basis of consciousness, he postulated that the substrate of consciousnes were double. By the nervous arrangements of the right posterio and/

and left anterior lobes he maintained that we learn the nature and position of the object which affects us. The nervous arrangements of the right anterior and left posterior lobes allowed us to learn the manner in which our organism is affected. He elaborated the distinction between subject and object consciousness by claiming that the activity of the substrata of subject consciousness always preceded that of the substrata of object consciousness which were thus higher in his hierarchy than those of subject consciousness.

From Jackson's work we derive the concept of functional levels in the central nervous system on which we base our ideas of the supremacy of cerebral cortex equating higher mental processes with higher levels of brain function. In the search for a "location" for consciousness there was a tendency to ignore lower or brain-stem centres as being of subsidiary importance and under the control of the more recently developed cortex. As will be discussed later the significance of brain stem may in fact be crucial.

Head (1926) did not concentrate only upon higher centres. He held that consideration of lower functional levels of nervous system could throw light on the nature and significance of consciousness, for even in decerebrate preparations such as a spinal cat, for example, a great degree of adaptative behaviour can occur. Head originally developed his concept of vigilance to apply mainly to spinal and mid brain levels

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but by analogy it came to refer to the operation of cerebral cortex on the basis that consciousness has the same relationship to the higher nervous centres as purposive reflexes have to lower nervous centres. Vigilance referred to the high grade state of physiological efficiency of any level of nervous system, and "When vigilance is high, mind and body are poised in readiness to respond to any event external or internal, but if it is lowered by injury, want of nutrition, chloroform or any other toxic influence, those high grade functions may suffer in general or in part, whether they are associated with consciousness or not". The last part of this quotation should be stressed to disaffirm that Head equated consciousness with vigilance.

The clinically based approach to consciousness starts from considerations of unconsciousness as a symptom. This negative term presents as many difficulties as the positive term and Jefferson (1944) feels that a new term is needed to define unconsciousness, traumatic or otherwise, which would designate more pointedly its nature and its pathological status in terms of neurophysiology. However, to do this a large number of terms would be required as unconscious patients differ profoundly in respect of such factors as the degree of unconsciousness, whether consciousness is lost fully or only in part, whether it is transient and fleeting, or prolonged and involves coma.

Martin/

Martin (1949) distinguishes two varieties of unconsciousness and disturbed consciousness: a) coma, related to sleep and to depressed cortical activity, and b) convulsive, related to irregular cortical discharges. He states that there appears to be no evidence of consciousness in man from the activity of other structures in the absence of cortical activity and that an impairment of activity of cortex over a wide area leads to unconsciousness. However, this activity of cortex is maintained in some vegetative fashion by the activity of the hypothalamus and unconsciousness may be caused by lesions of the hypothalamus.

In this, Martin seems to be merely restating the view that the activity of the cortex with which consciousness is associated is maintained by afferent impulses in sensory systems. However, he goes on to suggest that consciousness depends not only upon a process in which the cortex is kept in a state of activity by sensory impulses but also by an endogenous activation dependent upon the hypothalamus. The hypothalamus appears to be the driving influence of the cortex and is likened to the electric current which makes the wireless set live. Once the cortex is live it is capable of receiving and of interpreting sensory excitations without which the cortex is silent and consciousness cannot be demonstrated. This means that, although in theory consciousness might be maintained by/

by tactile, olfactory, gustatory, auditory and visual impulses arising from the environment, some excitation from the body itself is essential for the maintenance of consciousness. This modifies the assumption of a direct correspondence between "higher mental processes" and "higher nervous levels". The statement can still be made that consciousness is associated with the activity of the cortex which is, of course, different from saying that consciousness is an activity of the cortex.

Brain (1950) also hints that subcortical structures have an important role to play in the maintenance of consciousness: "Consciousness is linked with basal nuclei which made their appearance in the course of evolution millions of years before thought became possible, and since the days of our earliest vertebrate ancestors have sustained the life of the feelings."

Statements of this kind, which direct attention to the importance of non-cortical structures for consciousness, are precursors of the work on the ascending reticular system which originated "with the chance observation that direct electrical excitation of the reticular formation of the brain stem induced changes in the E.E.G. seemingly identical with those observed in awakening from sleep or alerting to attention". (Magoun, 1954). From this chance observation a great deal of work has developed with interdisciplinary significance. Such work is/

is reported currently in an International Symposium of the Henry Ford Hospital (Jasper, 1958) and previously in a symposium sponsored by the Council of the International Organisation of Medical Sciences (Delafresnaye, 1954).

The significance of the brain-stem reticular formation.

The reticular system of the brain stem is an ill-defined anatomical entity, histologically primitive and undifferentiated and well-developed in amphibious animals (Nauta and Whitlock, 1954). In the primates the system acts in conjunction with the diffuse thalamic projections to the cortex (Moruzzi and Magoun, 1949).

Cajal at the beginning of this century had observed significant differences in the reticular cells of the brain stem involving both sensory and motor collaterals and had concluded that not only do such cells have multiple influences operating upon them but even adjacent cells may have entirely different connections (Livingston, 1957). However, by the methods of study then available the brain-stem reticular system was generally found to be either unresponsive to stimulation or to yield apparently non-specific patterns of response.

This finding was, of course, not in keeping with the spirit of neurophysiological research which was until recent times dominated by localisation hypotheses and sought more refined/

refined knowledge of point to point relationships within the nervous system.

Magoun (1944) and others working on animals without central anaesthesia began to interest themselves in the functions of the reticular formation which seemed to be widespread in their effects. This led to a distinction within the nervous system between two general divisions - one comprising the "classical" sensory and motor pathways with relatively discrete functions and the other including the brain-stem reticular formation which appeared to have more generalised functions.

Moruzzi (1949), Jasper (1949) and Lindsley (1949) reported electrophysiological, neurophysiological and psychophysiological studies which showed that this brain-stem reticular formation had both a widespread inhibitory effect on spinal motor mechanisms and a generalised facilitatory influence. This latter facilitatory function of the reticular formation was referred to an ascending system of projections which tend to activate the cortex in a generalised fashion.

Further, the reticular formation is capable of modifying central excitatory states in a downwards direction. Livingston (1957) has shown that the cortex projects from certain discrete areas down into the reticular formation producing not only an interaction between descending impulses from the cortex and the sensory input, but also an interaction of certain cortical/

cortical fields with each other. He uses the term "a kind of Grand Central Station for the interaction of impulses generated in remote parts of the nervous system" to describe the complex activity of the reticular formation.

Thus it seems that certain cortical fields can be influenced in their activity by the intrinsic activity of the brain stem, and in their turn these individual cortical fields can exert patterns of influence upon this intrinsic activity either by diminishing or augmenting it. The picture is even more complex when the sequence of influence is shown to produce alternations of excitement and depression of such intrinsic activities. As Livingston (1957) puts it: "We are, therefore, provided with the comforting notion that the cortex is not simply the victim of whatever the reticular activating system might demand of it but the cortex itself possesses corticofugal regulating mechanisms which in turn can influence the level of activity within the reticular formation."

Evidence for this is supplied from the experiments of Segundo, Arana and French (1955) working in Magoun's laboratories. They have shown that electrical activation of certain cortical fields in monkeys immobilised by curare but free from the influence of central anaesthetic, induces the E.E.G. response characteristic of arousal. Also, naturally sleeping monkeys with implanted electrodes in such cortical fields are awakened and aroused behaviourally when stimulation

is/

is applied. However, electrical stimulation of cortical sites which do not project to the reticular formation fails to elicit such E.E.G. arousal or behavioural changes even though high intensities of current are applied. It seems, therefore, that corticofugal projections play a part in activating the rest of the brain via the reticular activating system. This is held to be so, not only in relation to arousal in response to specific stimuli but also for the maintenance of a centrally "aroused" state.

Investigations of sensory components suggested that the brain-stem reticular formation is also able to influence conduction along sensory paths (Moruzzi, 1956). For some time it has been recognised that recording of E.E.G. changes in response to sensory stimulation was easier from anaesthetised than from unanaesthetised animals. This is attributed to the fact that during anaesthesia the inhibiting action of the reticular formation upon afferent impulses along classical sensory pathways is interrupted. The sensory implications are specifically illustrated in the work of Hernandez-Peon, Scherrer and Jouvet (1956) on unanaesthetised cats with electrodes implanted in the dorsal cochlear nucleus to allow recording of auditory impulses. In the relaxed cat responses to a click could be recorded as a high amplitude localised electrical discharge. When, however, some mice in a jar were placed near the cat the amplitude of the discharges

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in response to the click-stimuli was markedly reduced while the animal's attention was directed to the mice. When the mice were removed and the cat was once more relaxed and inattentive responses to the clicks returned to their previous level.

They also found that if the click-stimulus was repeated and prolonged in the absence of reward or punishment cues the recorded potential was found to be reduced in accordance with the expected sensory adaptation or habituation effect. The interesting theoretical point here is that the psychological assumption that this habituation is perceptually determined is not confirmed, as it appears that the sensory pathways, conventionally held to be discrete up to the level of cortex, can in fact be influenced significantly at a level well below cortex by events occurring in the brain stem.

Such a formulation allows the beginning of an appreciation of how the central nervous system can provide some of the neural mechanisms underlying arousal and consciousness. The activity of the reticular activating system seems to be implicated both in the maintenance of "levels"of consciousness and also, because of its capacity for sensory control, in determining the "content" of consciousness.

Discussion.

This does not mean that a locus or "seat" of consciousness has/

has been found. This is philosophically unsatisfactory and is no more meaningful than attempting to ascribe the sound from a wireless set to a switch, a valve or a circuit rather than to operations which can be abstracted from all the components of the set. The neurophysiological work on the reticular activating system extends our psychophysiological concepts so that they become more consistent with the complexit; we have come to expect from the neural mechanisms underlying our capacity to adapt or our ability in Russell's words "to act with reference to what is distant in time or space even though it is not at present stimulating our senses". This work also suggests that consciousness should be viewed in a scalar or quantitative fashion along a continuum between coma and "clear" consciousness such as is suggested by Delay (1946) in his assertion that what we know as consciousness in man is an extrapolation of the primitive vigilance shared by a large part of the animal kingdom.

Previous attempts in psychology to formulate a rational basis for the neural mechanism underlying conscious processes have been unsatisfactory in that they have either led to a complete rejection of neurophysiological variables as with Skinner, or of consciousness itself as with the Behaviourists, or to an acceptance of a basic congruity between psychological and physiological processes as with the Pavlovians. While it may not solve the problem of the "seat" of consciousness this/

this neurophysiology is a fruitful source of new hypotheses and can provide a model of consciousness appropriate to psychology.

A model of consciousness.

The model of consciousness which can be derived from this work is a system in which complex patterns initiated by an input are controlled by central dominance and in which the direction of this central dominance is determined by some part of the input to the system. Its function in a biological sense is, therefore, regulatory. In electrical or mechanical terms the system would be a circuit or device whose operation provided a continuous series of equilibria. If we now transfer the regulatory nature of this system to the concept of consciousness itself we can arrive at the notion of regulatory consciousness. This term implies that it is no longer appropriate to regard consciousness as passive or epi-phenomenal as the conventional stimulus-response approach suggests.

Although it may be no more than sophistry it is worth while pointing out the paradox that, while we have a concept of dynamic unconscious processes in psychology, we still regard consciousness as a static and intangible quality. The new concepts in neurophysiology can allow us to think of consciousness in more dynamic terms and to say that it is the/

the characteristic whereby an individual's capacity to react adaptively can be maximised. It is akin to such concepts as vigilance, alerting or arousal although the technical use of these terms does not permit them to be synonyms for consciousness.

The significance of processes of attending in perception parallels the significance of dynamic regulatory consciousness for general behaviour in which an adjustment is maintained between the inner processes and environmental change. Hebb (1949, p.146) makes the point that "the most important mark of consciousness is the continual changing selective responsiveness to different aspects of a familiar environment, the unchanging responsiveness to unusual or unexpected events together with the continual presence of purpose...or motor equivalence!" However, the concept which is offered here of regulatory consciousness would stress that it is consciousness itself which provides the essential conditions for varying behaviour in an adaptive fashion.

Starting from the simple statement that the more information available to an individual the more likely is his subsequent behaviour to be adaptive, we can use an analogy between perceiving and statistical methods. The more adequate the information sampled the more likely is the resultant action to be appropriate and consciousness provides the best possible sampling/

sampling conditions for the required action. This allows the idea of consciousness as a continuum for it is not always appropriate to take the largest possible sampling which conditions of extreme novelty or threat would require. An ordinary everyday level of consciousness can be maintained on perceptual sampling well below the maximum possible sampling capacity. Similarly, disorders of consciousness can be viewed as situations in which the appropriate sample cannot be achieved and the consequent failure to adapt results from behaviour determined by this inadequate sampling. Many of the deficits reported in Investigation IV are examples of how errors can arise from faulty sampling. However, the danger in such an analogy is that one may think of the operation of regulatory consciousness purely in conventional perceptual terms, i.e. as being solely determined by the environmental cues.

The model of consciousness would of course involve the conventional afferent-efferent dimension, but would add the significant central regulatory mechanism which can produce activation in the absence of an input (i.e. other than intero-ceptive). As with all biological regulating systems equilibrium is achieved by balancing counter forces - in this case the activation from perceptual input and the inherent activation of the brain-stem reticular apparatus. This apparatus is capable at one and the same time of alerting

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the system appropriately in response to stimulation and of balancing the input to the state of alerting achieved.

Lindsley (1958) also takes the view that the reticular system is concerned in the mechanism underlying perceptual processes, and describes its possible roles as including "general arousal, general alerting, or attention; and specific alerting or focussed attention". This confirms the above interpretation of the two-fold action of this apparatus, consistent with the view that consciousness represents what we are aware of and also the conditions for our awareness.

THE MECHANISM OF E.C.T.

In the last 20 years during which E.C.T. has been in clinical use many views have been offered about its mode of action. Gordon in 1948 was able to report a collection of 50 shock therapy theories. Since then many others have appeared, including the following which have been noted during the survey of the literature relevant to this thesis: Riess (1948), Abse (1949), Flescher (1950), Weinstein, Linn and Kahn, (1952), Moulyn (1952), Wilcox (1954), Fabing (1955), Fleming (1956). While it would be a pleasant academic task to itemise, classify and discuss such theories, the results of such an undertaking would not be entirely relevant to the other work which has been reported.

That so many more or less pertinent theories can exist is due to the large number of possible approaches which can be made to E.C.T. Those who by bent or inclination favour the psychological approach arrive at psychological theories, others at physiological or humoral theories. Each basic scientist imports into the field his own characteristic need for an objective and demonstrable explanation of how E.C.T. works, sometimes to the despair of the clinician who may be influenced to have doubts about the status of his own empirical attitude to the treatment. The main obstacle to developing a satisfactory theory of E.C.T. is the existence of so/

so many varied observations that it is now almost impossible to suggest criteria on which to determine whether a given observation is directly relevant to the clinical action of the treatment or merely represents a secondary or side effect.

Faced with so many alternative theories one can at least take comfort from the feeling that one more will do no harm. It is, therefore, proposed to conclude by offering a formulation of the mode of action of E.C.T. on the basis of the observations previously reported and elaborated in discussion, that is, to try to indicate the mechanism of the treatment in terms of the operation of the reticular activating system.

To do this one starts with the concept of consciousness as a regulatory function as previously discussed. E.C.T., however, obviously does not directly increase this function as it serves to produce a series of deliberate abolitions of consciousness. The observations which were undertaken direct attention to the recovery processes both immediate and long-term rather than to the loss of consciousness associated with the convulsion. Although the degree of confusion and disorientation noted in patients appears to increase with successive shocks, the basic cognitive processes show an adaptation to repeated loss of consciousness before the end of the course is reached. The changes in convulsion duration and/

and in convulsive threshold previously discussed confirm the adaptive nature of the long-term reaction during a series of treatments. This suggests that within the treatment situation new equilibria can be achieved. This homeostatic effect does not operate significantly from the single convulsion. Because the clinical effect of treatment is only obvious after several shocks have been applied, a succession of recovery processes seems to be a requirement of clinical improvement. The cumulative effect of a course of treatment maximises a state of adaptative operation as opposed to the varying degree of maladaptation which the depressive illness occasions.

It is, therefore, suggested that in E.C.T. the non-specific massive and intense afferent input which abolishes consciousness, also produces subsequent arousal reactions which result in increased alerting over the course of treatments and that this sequence determines clinical improvement. This is merely the bald statement of an hypothesis. There are certain consequences which must be examined.

Firstly, such a formulation does not take account of the convention that a convulsion is necessary to alter the course of the depressive illness. This view has arisen from many sources. The originators of the treatment claimed that it was the convulsion itself and not the means of producing it that/

that mattered (see Section I). Chusid and Pacella (1952) and Negrin (1953) state that variations of form and frequency of the electrical stimulus are of secondary importance as long as the convulsion is produced. In cases where the E.C.T. apparatus has not delivered an adequate stimulus resulting in "sub-shock" or "stun" instead of the convulsion, improvement of the depressive illness is not achieved (Alexander, 1952). Thus Fleming (1956) is able to marshal such evidence to "demonstrate that a convulsion is the sine qua non in successful E.C.T."

On the other hand none of this evidence is crucial. It could equally well be claimed that the massive stimulation necessary to institute the regulatory processes necessary for recovery also initiates a convulsion. The convulsion would then be regarded as an "overspill" reaction to the electrical stimulus which is applied at a site at which its effects are widely diffused throughout the brain. It is in this sense that E.C.T. is described as involving a non-specific massive input.

Secondly, this view that E.C.T. produces an adaptive level of operation of the reticular activating system requires certain assumptions to be made about the nature of depressive illness. Particularly it implies that depressive illness involves some disturbance of alerting, or the maintenance of a subnormal level of alertness.

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This latter implication would repay a more detailed clinical study of illnesses involving depression of affect, particularly those for which E.C.T. is specific, in terms of alerting. For present purposes there are several existing studies which suggest that such a formulation is possible. For example, Campbell (1953) sees the constellation of manic-depressive symptoms as a group of discrete dysfunctions all of which tend to point to disorders at the diencephalic level of brain activity. The manifestations of such a primary level of disorder are autonomic and the variability in symptomatology between patients arises from the variations in balance in the activities of the sympathetic and para-sympathetic systems. "Symptom after symptom, time after time, the observer is impressed with the fact, from the patient's own descriptive terms, that in this disease there is an endogenous disturbance in central autonomic functions, some of which deviate one way, some another."

The autonomic changes noted in depressive illnesses are exploited by Funkenstein, Greenblatt and Solomon (1952) to produce a prognostic test for E.C.T. using the observation that a good E.C.T. prognosis correlates with the absence of a prompt recovery from Mecholyl-induced hypotension. This is going wider than the argument need take us but it raises the question of the relationship between autonomic activity and psychological functions with reference to psychoses.

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The nature of this relationship also arises within the field of experimental psychiatry, discussed elsewhere (Mowbray, 1958). The view of psychosis which this experimental approach fosters suggests a maladaptive process maintained by an afferent input insufficient to balance the inherent activity provided by the reticular activating system. This would be consistent with the hypothesis that E.C.T. modified the psychosis by restoring such a balance.

Kraines (1957) in an unconventional but stimulating discussion of mental depressions and their treatment implicates physiopathological processes in the aetiology of manic-depressive disorder, the psychic factors being secondary and modifying. His theoretical discussion does not indicate any specific aetiological mechanism but in the course of the discussion he assumes (p.505) that the depressive illnesses involve decreased "alerting" in Magoun's sense. To Kraines the depressive phase of the manic-depressive illness starts from a primary loss of "neural" energy which originates from a pathological but reversible dysfunction of the diencephalic-reticular systems. Again, it would seem likely that, where the determinants of the disease can be ascribed to dysfunction of the reticular system, the mechanism of its cure can be similarly ascribed.

Alexander (1958) also discusses the nature of depressive illness/

illness in particular stressing the role of anxiety. He uses a concept of warning-anxiety, similar to that outlined previously in this thesis (p.87) and postulates that "warning-anxiety has the power to overstimulate the cortical ego into panic or depression", depression being a paradoxical inhibitory reaction to excessive stimulation. E.C.T. can then be supposed to reduce the excitability of the central nervous system and thus to relieve depression by raising the cortical threshold of excitation. This formulation depends upon Pavlovian schemata in which "cortical substrates of ego" and "subcortical anxiety" are data but it has the considerable merit of being consistent with the observation that anxiety tends to increase during treatments and this may well be due to changes in cerebral excitability. As was previously argued (p.89) this biological as opposed to psychopathological anxiety is alerting, indicating once more the relevance of the activity of the reticular formation of the brain in depressive illnesses and consequently in their treatment.

CONCLUSION

There are many clinical and theoretical problems for which the new "neurophysiology of consciousness" offers hope of solution. None, however, is of greater importance than that of the mode of action of E.C.T.

There are few treatments in medicine more dramatic in their therapeutic effects. From year to year the value of E.C.T. is increasingly demonstrated, fortunately not dependent upon our knowledge of its mode of action. The work reported here derives its value heuristically as it directs attention to postulates drawn from a new orientation in our conception of the central nervous system, namely, the role of the reticular activating system in consciousness. It seems reasonable to assume that it is in this direction that future successful research into the mechanism of E.C.T. will be directed.

S E C T I O N IV

Statistical Appendices

A P P E N D I X A

FOLLOW-UP INVESTIGATION

Diagnostic Categories

Affective Disorders	217	=	60.5%
Depression of Epochs	60	=	16.7%
Depression with Psychoneurosis	31	=	8.6%
Psychoneurosis	44	=	12.3%
Miscellaneous	7	=	1.9%
	n = 359		100%

FOLLOW-UP INVESTIGATION

359 Cases with Age and Diagnosis Confirmed

Age	Total Group	Males	Females
15-19	6	3	3
20-24	24	11	13
25-29	55	22	33
30-34	60	31	29
35-39	48	23	25
40-44	41	22	19
45-49	50	23	27
50-54	33	10	23
55-59	23	9	14
60-64	15	7	8
65-69	4	1	3
	$n=\overline{359}$	$n=\overline{162}$	$n=\overline{197}$
	$\bar{x}=40.1$	$\bar{x}=39.2$	$\bar{x}=40.3$

FOLLOW-UP INVESTIGATION

Improvement on group with age and diagnosis confirmed

	Improved	Not improved		
Males	122	40	162	75.3%
Females	164	33	197	83.24%
	286	73	359	

$x^2 = 3.45$

$P = 0.06$ (marginally significant)

DIAGNOSIS WITH RECOVERY

	Improved	Not improved	
Affective disorders	181	36	217
Depression of epochs	51	9	60
	232	45	277

$X^2 = 0.08$

No significant difference $P = 0.75$

DIAGNOSIS WITH RECOVERY (contd.)

	Improved	Not Improved	
Affective disorders	181	36	217
Depression with psychoneurosis	20	11	31
	201	47	248

$x^2 = 6.3$

$P = 0.01$ (significant)

	Improved	Not improved	
Affective Disorders	181	36	217
Psychoneuroses	28	16	44
	209	52	261

$x^2 = 8.96$

$P = 0.006$ (significant)

DIAGNOSIS WITH RECOVERY (Contd.)

	Improved	Not improved	
Depression of epochs	51	9	60
Depression with psychoneurosis	20	11	31
	71	20	91

$X^2 = 5.00$

P = 0.02 (significant)

	Improved	Not improved	
Depression of epochs	51	9	60
Psychoneurosis	28	16	44
	79	25	104

$X^2 = 7.07$

P = 0.008 (significant)

DIAGNOSIS WITH RECOVERY (contd.)

	Improved	Not improved	
Depression with psychoneurosis	20	11	31
Psychoneurosis	28	16	44
	48	27	75

$X^2 = 0.006$

$P = 0.95$ (not significant)

Relationship between spontaneous complaint of memory difficulty and degree of improvement assessed.

	Improved	Not improved	
Memory difficulty	64	16	80
No memory difficulty	330	67	397
	394	83	477

$X^2 = 0.43$

$P = 0.5$ (not significant)

Relationship between spontaneously expressed fear of the treatment and degree of improvement assessed.

	Improved	Not improved	
Fear	58	5	63
No fear	336	77	414
	394	83	477

$X^2 = 3.76$

$P = 0.05$ (significant)

A P P E N D I X B.

FEAR OF TREATMENT

Age and Sex Distribution

Range	Male	Female	Total
15-19	0	0	0
20-24	0	1	1
25-29	3	5	8
30-34	3	3	6
35-39	2	8	10
40-44	3	8	11
45-49	1	3	4
50-54	2	3	5
55-59	2	3	5
60-64	0	0	0
65-69	0	0	0
	n = 16	n = 34	n = 50
	$\bar{x}$ = 40.1	$\bar{x}$ = 39.8	$\bar{x}$ = 39.9

FEAR of TREATMENT

Contingency Tables Derived from Table II.

Table II is basically a four by four representation. Because the numbers in each cell are small, it was decided to reduce the table to a two by two contingency table by splitting the ratings of improvement into the two categories of improved (much improved and improved) and unimproved (slightly improved and not improved). The rating of fear can be split up in two ways - a) into those patients reporting fear (+++, ++ and +) and those not reporting fear (0); and b) into those reporting significant fear (i.e. categories +++ and ++) and those reporting non-significant fear (i.e. + and 0).

Contingency Table (a)

		Not improved	Improved	
Fear	Category +++ ++ +	24	10	34
	Category 0	8	8	16
		32	18	50

With/

With Yates correction for continuity:-

		Not improved	Improved	
Fear	Category +++ ++ +	23.5.	10.5	34
	Category 0	8.5	7.5	16
		32	18	50

$X^2_c = 1.98$
P = 0.16 (not significant)

Contingency Table (b)

		Not improved	Improved	
Fear	Category +++ ++	3	14	17
	Category + 0	9	24	33
		12	38	50

With Yates correction for continuity:-

		Not improved	Improved	
Fear	Category +++ ++	3.5	13.5	17
	Category + 0	8.5	24.5	33
		12	38	50

$X^2_c = 0.14$
P = 0.70 (not significant)

FEAR of TREATMENT

Contingency Tables derived from Table III.

Difference between fear of treatment reported in group diagnosed as depression with psychoneurosis and group diagnosed (a) as affective disorders and (b) as psychoneuroses.

Table (a)

	Fear	No fear	
Affective Disorders	8	5	13
Depression with psychoneurosis	12	2	14
	20	7	27

With Yates correction :-

	Fear	No fear	
Affective Disorders	8.5	4.5	13
Depression with psychoneurosis	11.5	2.5	14
	20	7	27

$\chi^2 c = 0.96$

$P = 0.33$ (not significant)

Table (b)

	Fear	No Fear	
Psychoneurosis	14	8	22
Depression with psychoneurosis	12	2	14
	26	10	36

With Yates correction:-

	Fear	No fear	
Psychoneurosis	14.5	7.5	22
Depression with psychoneurosis	11.5	2.5	14
	26	10	36

$X^2c = 1.12$

$P = 0.27$ (not significant)

A P P E N D I X C

BEHAVIOUR DURING CONVULSIONS.

LENGTH OF TONIC PHASE.

Seconds	Males		Females		Total Group	
x	f	fx	f	fx	f	fx
7	1	7	0	0	1	7
8	1	8	1	8	2	16
9	0	0	2	18	2	18
10	1	10	3	30	4	40
11	0	0	0	0	0	0
12	4	48	8	96	12	144
13	0	0	2	26	2	26
14	2	28	1	14	3	42
15	4	60	4	60	8	120
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	1	18	0	0	1	18
	n=14	Σ=179	n=21	Σ=252	n=35	Σ=431
	(average 12.1 secs)		(average 12.0 secs)		(average 12 secs)	

DURATION OF FIT (measured from onset of convulsion to end of clonic phase).

Seconds	Males		Females		Total Group	
x	f	fx	f	fx	f	fx
33	1	33	1	33	2	66
34	1	34	3	102	4	136
35	0	0	2	70	2	70
36	0	0	0	0	0	0
37	2	74	3	111	5	185
38	2	76	0	0	2	76
39	1	39	3	117	4	156
40	3	120	4	160	7	280
41	2	82	1	41	3	123
42	1	42	1	42	2	84
43	0	0	2	86	2	86
44	0	0	1	44	1	44
45	1	45	0	0	1	45
	n=14	Σ=545	n=21	Σ=806	n=35	Σ=1351
	(average 38.9 secs)		(average 38.4 secs)		(average 38.6 secs)	

No significant difference between males and females

BEHAVIOUR DURING CONVULSIONS

LATIONSHIP BETWEEN LATENCY AND PRE-TREATMENT TENSION.

	Latency		
	Below average	Above average	
Tense	6	14	20
Not tense	11	4	15
	17	18	35

(Corrected for continuity)

	Latency		
	Below average	Above average	
Tense	6.5	13.5	20
Not tense	10.5	4.5	15
	17	18	35

$X^2c = 4.82$

$P = 0.03$

This relationship is significant.

BEHAVIOUR DURING CONVULSIONS

RELATIONSHIP BETWEEN TENSION AND CRY

	Pre-treatment		
	Tense	Not tense	
Cry	3	7	15
No Cry	12	8	20
	20	15	35

(Corrected for continuity)

	Pre-treatment		
	Tense	Not tense	
Cry	7.5	7.5	15
No Cry	12.5	7.5	20
	20	15	35

$X^2_c = 0.54$

$P = 0.48$

This relationship is not significant.

BEHAVIOUR DURING CONVULSIONS

RELATIONSHIP BETWEEN BODY BUILD AND LATENCY

		Latency		
		Below average	Above average	
Body Build	Heavier	7	5	12
	Lighter	15	8	23
		22	13	35

(Corrected for continuity)

		Latency		
		Below average	Above average	
Body Build	Heavier	6.5	5.5	12
	Lighter	15.5	7.5	23
		22	13	35

$X^2_c = 0.59$

$P = 0.48$

This relationship is not significant.

BEHAVIOUR DURING CONVULSIONS

RELATIONSHIP BETWEEN LATENCY AND STRENGTH OF CONVULSION

		Latency		
		Below average	Above average	
Rating of fit	Mild	12	7	19
	Strong	10	6	16
		22	13	35

(Corrected for continuity)

		Latency		
		Below average	Above average	
Rating of fit	Mild	12.5	6.5	19
	Strong	9.5	6.5	16
		22	13	35

$X^2_c = 0.15$

$P = 0.69$

This relationship is not significant.

BEHAVIOUR DURING CONVULSIONS.

RELATIONSHIP BETWEEN STRENGTH OF CONVULSION AND CRY

	Rating of fit		
	Mild	Strong	
Cry	9	6	15
No Cry	9	11	20
	18	17	35

(Corrected for continuity)

	Rating of fit		
	Mild	Strong	
Cry	8.5	6.5	15
No Cry	9.5	10.5	20
	18	17	35

$X^2_o = 0.29$

$P = 0.6$

This relationship is not significant.

BEHAVIOUR DURING CONVULSIONS

RELATIONSHIP BETWEEN PRE-TREATMENT TENSION AND STRENGTH OF CONVULSION

	Rating of Fit		
	Mild	Strong	
Tense	8	12	20
Not tense	10	5	15
	18	17	35

(Corrected for continuity)

	Rating of Fit		
	Mild	Strong	
Tense	8.5	11.5	20
Not tense	9.5	5.5	15
	18	17	35

$\chi^2_c = 1.78$

$P = 0.2$

This relationship is not significant.

BEHAVIOUR DURING CONVULSIONS

LATIONSHIP BETWEEN PRE-TREATMENT TENSION AND DISTURBED RECOVERY

		Recovery		
		Not disturbed	Disturbed	
treatment	Tense	14	6	20
	Not Tense	12	3	15
		26	9	35

(Corrected for continuity)

		Recovery		
		Not disturbed	Disturbed	
treatment	Tense	14.5	5.5	20
	Not tense	11.5	3.5	15
		26	9	35

$X^2_c = 0.078$

$P = 0.78$

This relationship is not significant.

RELATIONSHIP BETWEEN BODY BUILD AND PRE-TREATMENT TENSION

	Pre-treatment		
	Tense	Not tense	
Heavier	8	4	12
Lighter	12	11	23
	20	15	35

(Corrected for continuity)

	Pre-treatment		
	Tense	Not tense	
Heavier	7.5	4.5	12
Lighter	12.5	10.5	23
	20	15	35

$$\chi^2_c = 0.214$$

$$P = 0.60$$

This relationship is not significant.

A P P E N D I X D

RECOVERY OF CONSCIOUSNESS

Times of Correct Responses Ranked (from Table VI)

	Rank Order						
	A Average Group	B Quickest Times	d A-B	d^2	C Slowest Times	d A-C	d^2
Name	1	1	0	0	1	0	0
Address	2	3	-1	1	5	-3	9
Marital Status	2	2	0	0	2	0	0
Birth place	4	3	+1	1	3	+1	1
Year of Birth	6	8	-2	4	10	-4	16
Age	17	16	+1	1	16	+1	1
Father's name	8	7	+1	1	11	-3	9
Name of School	5	6	-1	1	4	+1	1
Picture description	11	5	+6	36	9	+2	4
Orientation for place	12	14	-2	4	12	0	0
Orientation for date	18	10	+8	64	16	+2	4
Orientation for year	15	10	+5	25	14	+1	1
Orientation for examiner	8	13	-5	25	6	+2	4
Right-left orientation	13	15	-2	4	13	0	0
Arithmetical problems	14	17	-3	9	15	-1	1
Sentence repetition	15	18	-3	9	16	-1	1
Digit repetition	8	10	-2	4	7	+1	1
Identifying objects	6	9	-3	9	8	-2	4
				$\Sigma d^2 = 198$			$\Sigma d^2 = 57$

$$\rho = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

ρ Average x Quickest = +0.79

ρ Average x Slowest = +0.89

APPENDIX E

C.F.F. and E.C.T.

Significance of the difference between mean thresholds (in c.p.s.) before and after E.C.T.

(Taken from Table VIII)

$$\text{Common Variance (C.V.)} = \frac{d^2 - \sum x\,d + d_1^2 - \bar{x}\sum d_1}{N_1 + N_2 - 2} = 10.8$$

$$\text{Standard Deviation of the difference of the means (S.D.)} = \sqrt{\frac{C.V.}{N_1} + \frac{C.V.}{N_2}} = 0.94$$

$$\text{Ratio (t)} = \frac{\bar{x}_1 - \bar{x}_2}{S.D.} = 3.4$$

$$\text{Degrees of freedom (n)} = N_1 + N_2 - 2 = 46$$

The probability taken from distribution tables in Fisher and Yates (1953) shows a P value corresponding to the 0.001 level. That is, the difference between the means cannot be ascribed to chance.

APPENDIX F

MATRICES SCORES

Variances calculated from Table X

Column	n	Σx^2	$\frac{\Sigma x^2}{n}$	$\frac{(\Sigma x)^2}{n}$	$\sigma^2 = \frac{x^2}{n} - \frac{(\Sigma x)^2}{(n)}$	$n\sigma^2$	
1	18	153	8.48	4.20	4.28	75.6	
2	18	115	6.39	2.96	3.43	61.7	
3	17	73	4.30	0.52	3.78	63.2	
4	17	66	3.88	0.06	3.82	64.9	
5	12	100	8.33	0.44	7.89	94.5	
6	7	62	8.86	0.72	8.14	57.0	
7	5	27	5.40	1.44	3.96	19.8	436.7
8	18	163	9.05	2.59	6.46	116.3	
9	18	157	8.72	3.35	5.37	96.6	

Total variance columns $1 \rightarrow 7 = \frac{\Sigma n\sigma^2}{N-4} = \frac{436.7}{90} = 4.85$

$\sqrt{\quad} = 2.2$

A. Comparing Session I with Session II

	n	Σx	$\bar{x}$	Σx^2	$\frac{\Sigma x}{n} = 6$
I	18	37	2.1	153	2.06
II	18	-31	-1.7	115	1.85
			diff. = 3.8		

Standard error of means $= 2.2\sqrt{\frac{1}{18} + \frac{1}{18}}$

$= 0.73$

$t = \frac{3.8}{0.73} = 5.2$

degrees of freedom = 18 + 18 -2 = 34

P corresponds to 0.001 (highly significant)

B. Comparing Sessions II and III with VI and VII

	n	Σx	$\bar{x}$
II and III	35	-44	-1.26
VI and VII	12	13	+1.08
		diff. =	2.34

Standard error of means = 0.74

$$t = \frac{2.34}{0.74} = 3.16$$

Degrees of freedom = 35 + 12 - 2 = 45

P corresponds to a value of 0.01 (significant)

C. Comparing Sessions 1 with VI and VII.

	n	Σx	$\bar{x}$
I	18	37	2.10
VI and VII	12	13	1.08
		diff. =	1.02

Standard error of means = 0.82

$$t = \frac{1.02}{0.82} = 1.24$$

Degrees of Freedom = 28

P lies between 0.3 and 0.2 (not significant).

D. Comparing Session 1 with 1st Session after treatment (i.e. column 8).

	n	Σx	$\bar{x}$
Session 1	18	+37	2.1
Column 8	18	+29	1.6
		diff. =	0.5

Standard error of means = 1.85

$$t = \frac{0.5}{1.85} = 0.24$$

Degrees of freedom = 34

P lies between 08 and 09 (not significant).

LEARNING PAIRED ASSOCIATES.

Deviations from individual averages (Taken from Table XI)

	DEVIATIONS								
	Meaningful					Semi-Meaningful.		
	Treatment.			Post-treatment		Treatment.		
Patient	I	II	III	I	II	I	II	III
A	-14	-12	+26	+14	- 5	-12	+ 6	+ 6
B	+ 2	-10	+ 8	+ 3	- 3	+ 4	+ 7	+19
C	+ 2	- 2	0	+ 9	- 8	- 9	- 3	+13
D	- 3	- 5	+ 7	+ 9	- 8	-12	-	+12
E	- 4	- 2	+ 5	+ 1	- 2	-16	+15	-
F	- 4	- 6	+10	+14	-12	- 7	- 3	+10
G	- 7	- 4	+12	- 2	+ 2	-13	+ 4	+10
H	0	- 6	+ 5	- 1	+ 3	- 3	+ 1	+ 2
I	- 1	- 2	+ 2	- 2	+ 3	-	-14	+15
J	+ 2	- 5	+ 4	+ 7	- 6	- 2	- 5	+ 6
K	+ 3	- 2	- 2	+ 9	- 8	- 6	-	+ 5
L	- 2	- 5	+16	+12	- 4	- 9	- 8	+18
M	- 2	- 6	+ 8	0	0	-12	+ 8	+ 5
N	- 1	+ 1	+ 1	- 4	+ 3	-13	+ 2	+10
O	-10	- 7	+18	+ 6	- 5	-14	-	+13
P	- 1	+ 1	-	+ 4	- 4	- 9	+ 2	+ 8
Q	- 9	- 9	+17	+ 6	- 7	-10	- 8	+18
R	- 1	- 1	+ 3	+ 2	- 3	-	- 7	+ 6
Totals	-50	-82	+144	+98	+64	-143	- 3	+176
n	18	18	17	18	18	16	15	17
A devn.	-2.8	-4.6	+8.5	+5.4	+3.5	-8.9	-0.2	+10.3
d^2	500	580	1650	903	553	1679	815	1942

Meaningful. Treatment

$\sigma^2_{I} = 19.69$

$\sigma^2_{II} = 11.06$

$\sigma^2_{III} = 24.81$

Post-treatment

$\sigma^2_{I} = 21.00$

$\sigma^2_{II} = 18.46$

$\Sigma\sigma^2 = 95.02$

Common variance $= \frac{95.02}{85} = 1.12$; $\sigma = \sqrt{1.12} = 1.06$

Comparing Treatment Session I with Session II

S.E. diff. means $= 1.06\sqrt{\frac{1}{18} + \frac{1}{18}} = 0.35$

$t = \frac{1.8}{0.35} = 5.1$

degrees of freedom = 34. P = 0.001 (highly significant).

(Contd.)

This level of significance is calculated for the smallest difference between means in the meaningful sessions, with the exception of the difference between Treatment I and post-treatment which is not significant. All other differences can then be taken to be significant.

Semi-meaningful.

$$\sigma^2_{I} = 25.7$$
$$\sigma^2_{II} = 54.2$$
$$\sigma^2_{III} = 8.1$$
$$88.0$$

Common variance = 1.95

$$\sigma = \sqrt{1.95} = 1.39$$

From this the t values yield significances for the difference in means.

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