EARLY ENVIRONMENT EFFECTS ON RAT PHOTIC EVOKED POTENTIALS: A PRELIMINARY STUDY

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Several recent studies (6, 4, 19) have shown a significant relationship between photic evoked potentials and psychometric measures of intelligence, leading to the expectation that cortical *PEP*[1] will be used increasingly in the measurement of intelligence.

In this context, it is the purpose of the present study to investigate whether *PEP* are significantly affected by the environment in which the individual has developed. The albino rat has been chosen as experimental subject because it develops rapidly and permits strict control of its developmental environment.

EVOKED POTENTIALS AND INTELLIGENCE

In a preliminary investigation of this relationship in human subjects, Ertl (6) found a correlation of -0.88 between *PEP* latencies and intelligence. Subsequently, using a zero crossing technique (7) for latency analysis, Chalke and Ertl (4) found significant differences in the *PEP* latencies of forty-eight subjects divided into high, average and low intelligence groups. More recently Taylor (19), using Otis scores as measure of intelligence, has found a significant correlation of -0.68 between intelligence and *PEP* latency.

ENVIRONMENT AND BEHAVIOUR

An exploratory project by Hebb (9) concerning the effects of early environment on behaviour has given rise to a number of related studies on rats and dogs, the most significant of which were performed by Clarke *et al.* (5), Bingham and Griffiths (2), Hymovitch (10), Forgays and Forgays (8), Thompson and Heron (20) and Woods (21). The literature on the effects of early environment on the behaviour of animals has been thoroughly reviewed by Beach and Jaynes (1). These studies are unanimous in the finding that, when groups of animals are brought up in environments of differential complexity, significant differences can be demonstrated in the behavioural efficiency of the groups. These studies suggest effective methods for affecting the behavioural efficiency of laboratory animals through early environmental enrichment or impoverishment.

[1] The abbreviation *PEP* will be used to denote photic evoked potential.

ENVIRONMENT AND BRAIN CHEMISTRY

The following series of studies by Krech, Rosenzweig and associates explores the effects of differential environments similar to those described in the above behavioural studies on the cholinesterase activity of the brain. In the first of these studies, Krech *et al.* (12) report the preliminary finding that behaviourally efficient rats show at autopsy a higher brain cholinesterase level than less efficient rats.

This finding was extended through a series of investigations by Krech *et al.* (13, 14) and Rosenzweig *et al.* (16, 17, 18), which concluded that environmentally enriched rats are not only superior problem-solvers as compared to environmentally deprived litter-mates, but show significant differences in brain weight, cortical cholinesteras level, and cortical/subcortical cholinesterase ratio. The cholinesterase differences found when comparing environmentally enriched and deprived subjects are interpreted to reflect differences in synaptic activity brought about by differential environments.

RESEARCH HYPOTHESIS

Based on the findings that there is a significant relationship between intelligence and evoked potentials, that differential environments produce significant behavioural efficiency differences in lower animals, that differential environments produce significant differences in brain cholinesterase activity, the experimental hypothesis is advanced, stated here in its null form, that: When a group of rats raised in an enriched environment is compared to a group raised in an impoverished environment, no significant differences develop in the photic evoked potentials of the groups during the first three months of life.

METHOD

SUBJECTS:

Sixteen male Sprague-Dawley albino rats were used, from four litters born within a twenty-four hour period. They were separated into enriched and impoverished groups at twenty-one days, using the split-litter technique.

APPARATUS:

Enriched and impoverished environments were designed in general accordance with those used by Hymovitch (10). The enriched environment consisted of a large cage measuring 60" by 30" by 12", containing toys which were periodically changed. The impoverished environment consisted of small, bare, individual cages measuring 12" by 7" by 6" each. Both enriched and impoverished subjects were supplied with water and Master laboratory cubes, and all cages had access to light and air.

For recording of *PEP*, an *E & M* restraining apparatus was used to immobilize the subject and permit the use of scalp electrodes. A Tektronix Differential Amplifier Type 2A61, containing a filter with an attenuation slope of 6 db per octave roll-off, set to filter responses 3 db down at 6 cps and 60 cps, led from the subject to an active filter with an attenuation slope of 24 db per octave roll-off, set 3 db down at 100 cps. This filter was connected both to an oscilloscope for monitoring and to a computer of average transients set to average 250 msec. sweeps following photic stimulation. Photic stimulation was produced through a Nihon Kohden photic stimulator triggered manually with a Rutherford B14-R pulse generator which was connected also to the computer of average transients. A Polaroid camera equipped with Fairchild oscilloscope attachment was used to photograph each subject's averaged wave train as displayed from the averaging computer on the oscilloscope.

PROCEDURE:

The subjects were separated into enriched and impoverished groups at twenty-one days of age, using the split-litter technique. They were reared in their respective environments to the age of three months. During this period, the impoverished subjects were handled only for the purposes of cleaning the cages and recording their *PEP*. The enriched subjects, on the other hand, experienced daily contact with the investigators.

PEP records of all subjects were obtained three times during the experimental period, at four-week intervals. The first records were made two weeks after the establishment of differential environments. Each subject was restrained in a transparent rat holder, and, after it ceased to struggle violently, had two Grass needle electrodes placed in its scalp 2 mm. apart, on a sagittal plane half-way between the midline and the base of the right ear lobe, the posterior electrode being 2 to 5 mm anterior to the inion depending on the size of the rat at the time. In this way the electrode placements suggested by Kimura (11) and by Pickenhain and Klingberg (15) were approximated.

Once the animal quieted, its *PEP* to 120 flashes of constant intensity and duration, triggered manually at approximately 2 second intervals, were recorded. For latency analysis, 250 msec sweeps following each stimulation were recorded and averaged in a computer of average transients, displayed on an oscilloscope screen, and photographed. Each photograph was identified with a code number.

After all photographs for each occasion had been obtained, the latency of the event in each photograph which was of greatest amplitude and neither less than 25 msec. nor more than 75 msec. was read

to the nearest msec. It was considered that latencies below 25 msec. could be of myogenic origin, and it was found through a pilot project that those above 75 msec. did not reproduce reliably. Figure 1 represents the *PEP* records of two subjects on each of three occasions.

As this was a preliminary study, it was considered adequate by way of statistical analysis of *PEP* latencies to compare the Mean latencies of the enriched and impoverished subjects on each of the three occasions, using a t test.

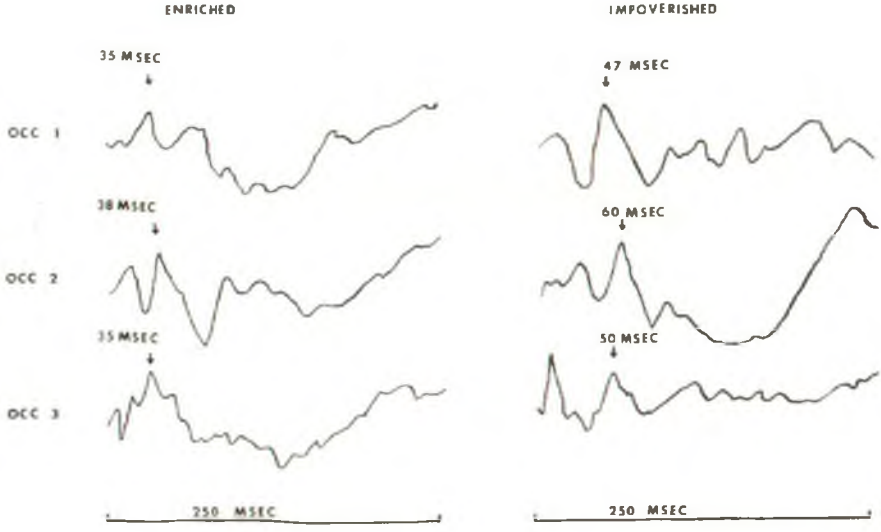

FIGURE 1— PHOTIC EVOKED POTENTIALS OBTAINED FROM TWO ALBINO RATS, ONE REARED IN AN ENRICHED ENVIRONMENT AND THE OTHER IN AN IMPOVERISHED ENVIRONMENT, ON THREE OCCASIONS AT MONTHLY INTERVALS, BEGINNING TWO WEEKS AFTER THE ESTABLISHMENT OF DIFFERENTIAL ENVIRONMENTS.

RESULTS

The results of this investigation are summarized in Table 1. On the first occasion, two weeks after the start of the experiment, the mean *PEP* latency of the enriched group was 37.2 msec., that of the impoverished group was 46.4 msec., the difference between the means was 9.2 msec., and the t test yielded a value of 3.99, significant beyond the 0.01 level of probability.

TABLE 1

Comparison of Mean Photic Evoked Potential Latencies[a] in Enriched and Impoverished Groups of Rats, Using a t Test for the Significance of a Difference Between Means on Non-Independent Small Groups.

Occasion[b]	Enriched Group		Impoverished Group		Difference of Means	t	Significance
	N	M	N	M			
First	8	37.2	8	46.4	9.2	3.99	> 0.01
Second	8	37.5	8	57.8	20.3	8.14	> 0.001
Third	8	42.2	8	52.2	10.0	5.26	> 0.001

a Mean Photic Evoked Potential Latencies are measured in milliseconds following the onset of photic stimulation.

b Evoked potentials were recorded on three occasions, the first, two weeks after the start of the experiment, and the next two at four-week intervals.

On the second occasion, four weeks later, the mean *PEP* latency of the enriched group was 37.5 msec., that of the impoverished group was 57.8 msec., and the difference between the two was 20.3 msec. The t test yielded a value of 8.14, significant beyond the 0.0001 probability level.

On the third occasion, ten weeks after the start of the experiment, the mean latency values obtained were 42.2 msec. and 52.2 msec. for the enriched and impoverished groups respectively. The difference between the means was 10.0 msec., and the t test yielded 5:26, significant beyond the 0.001 level of probability.

DISCUSSION

On the assumption of equivalent groups at the start of the experiment, it is the tentative finding of the present study that rearing in an impoverished environment results in a significant increase in *PEP* latencies. The direction of the results is in agreement with previous findings on humans (6, 4, 20) that less intelligent subjects exhibit greater *PEP* latencies, and with Bradley's (3) finding that cretinized rats, which may be expected to be behaviourally inferior, also show greater latency in their evoked responses than control rats.

In the context of the studies reviewed on the relationship between differential environments and brain chemistry, the authors interpret both the cholinesterase differences previously found by Krech, Rosenzweig and Bennett, and the differences in *PEP* latencies found in the present study, as reflecting differences in efficiency of brain function brought about by rearing in differential environments.

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ABSTRACT

This study was designed as a preliminary investigation of the effects of differential early environments on the photic evoked cortical potentials of the albino rat, recorded from the scalp of unanesthetized subjects.

A sample consisting of sixteen male Sprague-Dawley albino rats was subdivided at weaning, by means of the split-litter technique, into two groups. One of the groups was reared in an enriched environment, to the age of three months. During this time records of the photic evoked potentials of all subjects were obtained three times, at monthly intervals.

The authors found a significant difference in the mean photic evoked potential latencies of the groups, and on this basis rejected the experimental hypothesis, which in its null form states that when a group of rats raised in an enriched environment is compared to a group raised in an impoverished environment, no significant differences develop in the photic evoked potentials of the groups during the first three months of life.

RESUMEN

Este estudio se concibió como una investigación preliminar de los efectos del diferencial ambiental sobre el potencial cortical fótico de la rata albina, registrado del cuero cabelludo de los sujetos, sin anestesia.

Un grupo-muestra compuesto de 16 albinos, machos Sprague-Dawley, fue subdividido durante el destetamiento, por medio de la técnica "split-litter", en dos grupos. Uno de estos grupos fue criado en un ambiente enriquecido mientras que el otro fue criado en un ambiente empobrecido, hasta los tres meses de edad. Durante este tiempo, se obtuvo el record del potencial fótico de todos los sujetos tres veces, a intervalos de tres meses.

Los autores encontraron una diferencia significante en el promedio del potencial fótico de los grupos, y en base a esto rechazaron la hipótesis experimental, que en su forma nula indica que cuando un grupo de ratas criado en un ambiente enriquecido se compara con un grupo criado en un ambiente empobrecido, no se desarrollaron importantes diferencias en el potencial fótico de los grupos durante los tres primeros meses de vida.

RESUMO

O presente estudo foi planejado em têrmos de uma pesquisa preliminar sôbre os efeitos de ambientes de infância diferentes no potencial cortical fótico evocado do rato albino, registrado no escalpo de sujeitos não-anestesiados.

Uma amostra de 16 ratos albinos Sprague-Dawley (machos) foi subdividida em dois grupos na ocasião do desleite, usando-se a técnica "split-litter". Um grupo foi criado em um ambiente enriquecido, e o outro num ambiente empobrecido, até a idade de três meses. Durante êste período potenciais fóticos evocados para todos os sujeitos foram registrados três vêzes, em intervalos de um mês. Diferênças significativas entre as latências médias dos potenciais fóticos evocados dos dois grupos foram encontradas.