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Information Processing Deficits in Post Concussion Syndrome

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Abstract

Stimulus processing and response programming aspects of information processing were examined in patients with post concussion syndrome and a comparable group of normals. Patients had higher recognition thresholds (serial processing), poorer parallel processing and longer choice reaction time (complex response programming). Simple reaction time was comparable to that of normals. The findings demonstrate different loci of information processing in patients with post concussion syndrome.

Key words -

Post Concussion Syndrome,
Information processing deficits,
Subtle Neuropsychological dysfunctions

Post Concussion Syndrome (PCS) characterized by symptoms of headache, giddiness, noise intolerance, anxiety, depression, poor memory and concentration and irritability [1] is the most common sequelae after head injury [2]. Aetiological factors described have been Psychosocial [3], [4], and Organic [5] as well as a combination of the two [2]. Subtle neuropsychological dysfunction in the form of information processing deficits [6] is one of the organic factors reported.

Delays in serial auditory information processing have been demonstrated in head injury patients and this persists longer than usual in those patients who develop PCS [6]. Locus of the deficit has not been identified with reference to the stimulus processing or response programming aspect of information processing. Studies on head injured patients have shown deficits at the stimulus processing stage in terms of slowed tachistoscopic perception of stimuli [7]. Deficits of complex response programming reflected in slowed choice reaction time has also been observed [8]. Again these deficits of stimulus processing and response programming have not been studied in PCS. In view of the association between PCS and information processing deficits, an analysis of these deficits in PCS in terms of stimulus processing and response programming stages of information processing would be useful to understand the precise nature of the deficit and its aetiological relationship.

This present study examined serial and parallel stimulus processing as well as simple and complex response programming aspects of information processing in PCS. Serial and parallel stimulus processing were examined by the recognition threshold test and the span of apprehension test respectively. Simple and choice reaction time tests examined the simple and complex aspects of response programming respectively. The four tests were administered to patients with the diagnosis of PCS [1] as well as to a comparable group of normal controls.

Recognition Threshold Test

Sample: 30 patients and 30 normals completed the test. The characteristics of the patients group are, age ranged from 17-43 years (mode=30 years), education ranged from 2-17 years of schooling (mode=10 years), duration of unconsciousness after injury ranged from few seconds to 4 days (mode=10 mns). Duration between injury and testing from 2 months to 5 years (mode=1 year). 5 of the patients were females. 18 were on psychotropic medication at the time of testing. 21 had suffered from concussion, 8 from contusion and 1 from primary brain stem injury. The normal group was comparable to the patient group in age, educational status and sex ratio.

Procedure

One of the four single digit numbers (2, 3, 5 and 6) formed the stimulus. Each was 9 mm high and 5 mm wide. Stimulus was presented at the centre of the visual display unit of a computer and viewed by the subject (patient or control) from a distance of 2 1/2 meters. Responses were recorded on a button console consisting of four corresponding buttons arranged in the form of a cross, with a fifth central dummy button, on which the finger rests. The test consisted of eighty trials wherein each of the four stimuli was displayed 20 times. Each stimulus was displayed equally at each of these stimulus durations: 20 milliseconds (ms), 40 (ms), 80 (ms), 160 (ms), 320 (ms), 640 (ms), 1280 (ms) and 2560 (ms). The order of display of stimuli and the stimulus durations was randomized. Each trial commenced with the appearance of a '+' as the fixation point, 250 milliseconds preceding the appearance of the stimulus at the same locus. Inter trial interval was 5 secs. Before the test the subject was shown the stimuli for long periods so that he could become familiar with the stimulus and the appropriate response button. He was told that the stimuli appeared randomly. He pressed the appropriate button upon the disappearance of the stimulus. The number of stimuli correctly identified at each of the stimulus durations formed the score.

Span of Apprehension Test

Sample :

8 patients and 8 normals completed the test. In the patient group age range from 17-40 years (mode=25 years) duration of unconsciousness was from few seconds to 4 days (mode=10 mns) and duration between injury and testing 2 months to 6 years (mode=2 years). None of the patients were on psychotropic medication and all had suffered from concussion. One patient was a female. The normal group was comparable in terms of age, educational status and sex ratio.

Procedures:

An array of 9 single digit number (1-9) arranged in 3 rows and 3 columns was displayed on the visual display unit of the computer system. Each digit was 9 mm high and 5 mm wide. 8 such arrays with different ordering of the numbers were programmed to appear randomly. The subject viewed the screen from a distance of 1 ½ meters. The test consisted of 40 trials. Each trial commenced with an auditory alarm followed immediately with an auditory alarm followed immediately by the stimulus display for a duration of 200 milliseconds. The 8 arrays appeared equally often. The inter-trial interval was 5 seconds. The subject was asked to scan the entire array and report all the numbers identified for each trial.

Reaction Time Tests

Sample :

8 patients and 8 normals completed the two tests of simple and choice reaction time. In the patient group the age ranged from 24-38 years (mode=30 years), education from 2-15 years of schooling (mode=10 years), duration of unconsciousness from few seconds to 2 days (mode=10 mns) and duration between injury and testing 6 months to 3 years (mode=2 years). 4 of the patients were on psychotropic medication and 3 were females. 6 had suffered from concussion, 1 from contusion and 1 from primary brain stem injury. The normal group was comparable in terms of age, educational status and sex ratio.

Procedure - Simple Reaction Time Test

The stimulus was a single digit (2) of 14 mm height and 9 mm width displayed on the center of the visual display unit, preceded by a fixation stimulus by 250 ms. The stimulus was viewed from a distance of 1 1/2 meters. The computer was programmed to deliver a 80 ms. stimulus and record the reaction time. The test consisted of 80 practice trials, followed by 5 minutes pause and 80 test trials. Subject was required to press the top button of the console as quickly as possible after the disappearance to the stimulus i.e., the reaction time. This was averaged over the 80 test trials.

Procedure - Choice Reaction Time Test

The stimulus was one of the four single digit numbers (2, 3, 5 or 6) each of 14 mm height and 9 mm width, which appeared in the center of the visual display unit, 250 milliseconds after the fixation stimulus, for a duration 20, 40, 60 or 80 milliseconds. There were a set each of practice trials and test trials with a pause of 5 minutes in between.

In each set, each of the stimuli appeared on 20 occasions in each of the stimulus durations. The order of the stimuli as well as the stimulus duration were randomised. The subject was required to press the appropriate button on the console as quickly as possible after the stimulus disappeared i.e., the reaction time. The computer was programmed to deliver the stimuli, record the reaction times and average the reaction times at each of the four stimulus durations. The computer used in all these tests was a PSI action station computer.

Results

Recognition threshold:

Mean number of correct responses (MNCR) at each stimulus duration of patients and normals is presented in Table 1. Analysis of variance (ANOVA) with repeated measures was performed. The group effect, (F=90, df=1, < .01) stimulus duration effect (F=32.4, df=7, P < .01) and the group stimulus duration interaction effects (F=4.7, df=7, P < .01) were significant. Patients score below the normals at all the stimulus durations (Group effect). MNCRs in both the groups improve with the stimulus durations (stimulus duration effect). The MNCRs of the patients are particularly lower than that of the controls at the lower stimulus durations (Fig) (Interaction effects). The latter finding suggest a less efficient processing at these durations by the patient group.

Table I - Mean Number of Correct Responses (MNCR) of patients and normals

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Figures in parentheses are standard deviations

.Mean number of current responses at the successive stimulus durations for patients with post concussion syndrome and normals (n=30 each). Patients perform worse at lower stimulus durations (Ref. also Table I).

The average no. of correct responses for each patient was calculated over all the stimulus durations, which represented the efficiency of stimulus processing for each patient. Medicated (N=12) and unmedicated (N=18) did not differ in the efficiency of stimulus processing (Means are 7.3 and 7.5 respectively, t=.06, NS). Severity of injury also did not affect the efficiency. The concussed group (N=21, Mean=7.3) and the contused group (N=.9, Mean=7.5) did not differ significantly (t=.0005, NS). Further the duration elapsing between injury and testing did not affect the efficiency of stimulus processing. The older cases (N=15, Mean=7.5) and the recent cases (N=15, Mean=7.2) did not differ significantly (t= 0.38, NS).

Span of Apprehension

The average numbers seen by the patients over 40 trials was 77 and that by normals was 125. Patients have been significantly lesser numbers than normals (t=3, df=4, P < 0.02).

Simple Reaction Time

Mean reaction times of patients (374 ms; SD=115) was not significantly different from that of normals (314 ms; SD=101). Patients are as fast as normals when a simple motor task is required.

Choice Reaction Time

Mean reaction times of patients and normals are given in Table II. ANOVA with repeated measures done on this data indicated that patients were slower than normals at all stimulus durations (significant group effect). The stimulus durations however, do not change the reaction time in either group. Hence the average choice reaction time over the four stimulus durations was calculated for each subject. (Patients=710 ms, Normals=613 ms). Medication did not affect reaction time.

Table II - Mean Choice Reaction time of patients and normals at the four stimulus duration

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Figures in parentheses are standard deviations

Correlation between different tests

8 patients had completed both the detection threshold and span of apprehension test, while 8 other patients completed the detection threshold test as well as choice reaction time tests. In the first 8 the relationship between serial and parallel processing could be examined, while in the latter 8 the relationship between stimulus processing and response programming could be examined. Similar data on two groups of comparable normals of 8 each was also available.

The average number of correct responses (ANCR) over the eight stimulus durations calculated for each subject in the detection threshold test, was correlated with the numbers seen in the span of apprehension test, using the rank difference method. While the correlation was poor in patients (0.19), it was high in normals (0.62) ($P < 0.02$). This indicates a dissonance between the two processing strategies in patients, but not in normals.

The ANCRs of each subject was correlated with the average choice reaction time, using a similar procedure. In patients (0.37) as well as normals (0.18) the correlations were poor and non-significant, indicating that these two processes are unrelated.

Discussion

The findings of this study agree with other observations in head injured patients like that of Reusch [9], who found impairment in visual tachistoscopic perception, and Macflynn et al [8]. who found increased choice reaction time. The results however disagree with Benton and Blackburn [10] who found delay in simple reaction time also. The relationship between different stages of processing in post concussion syndrome patients has not been hitherto studied. It is significant that factors like medication, severity of injury and the time lapse after head injury do not affect these deficits.

The presence of neuropsychological deficits in the form of deficits in information processing, in patients with post traumatic syndrome strongly favours the organic nature of the syndrome. The poorer efficiency of information processing due to deficits at stimulus processing and response programming stages results in an information overload. This information overload has been considered as an aetiological factor in the development of some of the PCS symptoms like irritability, fatigue, poor memory and concentration [6]. However the genesis of the syndrome from such deficits cannot be concluded until a group of similarly head injured patients without post traumatic syndrome are studied.

A possibility of poor motivation due to the presence of symptoms, being responsible for such deficits can be reasonably excluded, as there was no evidence of scatter and further the patient group did the simpler test as well as the normals. However, testing a group of non head injured neurotic patients with similar cluster and degree of symptoms should throw more light on this matter. Although we agree with the earlier views [6] that such deficits lead to information overload and hence the subjective symptoms of post traumatic syndrome, we go further ahead to point to certain qualitative aspects of these deficits. Of importance is the dissociation between the serial and parallel processing abilities noticed in the patients as against the normals. Needless to say further work has to go in before we understand the role of information processing deficits in head injured patients.

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