Article NIMHANS Journal

Divided Attention in Head Injury

Volume: 12 Issue: 02 July 1994 Page: 157-162

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Reprints request

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Abstract

Divided attention was studied in terms of attentional capacity and strategy of attentional resource allocation in mild head injury. Nineteen patients with concessive closed head injury, who had symptoms but no neurological deficits were compared with 19 normal controls. Two paradigms of dual task performance was employed which differed in the degree of overlap between attention resources. Performance on the tasks when given singly indicated depicted attentional resource capacity in patients. Dual task performance indicated that division of attention was possible in patients irrespective of the degree of overlap among resources. Strategy of attentional resource allocation was sub-optimal in patients and was not related to symptom severity. Division of attention could be an intermittent process in everyday life. Hence though deficient and requiring compensatory effort from the patient it is not associated with symptoms.

Key words -

Attention,
Closed head injuries,
Cognition disorders,
Head injuries,
Neuropsychological tests

Cognitive deficits are a sequelae of head injury. Deficits of information processing, memory and attention are reported even in mild head injury [1], [2], [3], [4], [5]. Patient compensates for the deficits by spending a greater effort. When this compensatory effort becomes chronic, it acts as a stressor and symptoms develop [1], [2], [3], [4], [5], [6], [7]. Majority of studies on cognitive deficits have focussed on memory, perception, language and intelligence [8], [9]. Studies of attention deficits have been few. Selective attention is impaired in terms of capacity to withstand distraction [6], [10]. The distraction effect is explained as a divided attention deficit, in terms of a response conflict in the dual task [5]. Divided attention deficits have been postualted to explain poor performance on complex cognitive tasks following head injury [11]. Though divided attention deficits have been postulated, it has not been directly measured in head injury patients. The multiple resource model of attention gives scope for measuring attentional capacity and strategy of allocation. Attentional capacity is measured by varying the degree of attentional allocation to a single task. Strategy of resource allocation is measured by dividing the resource pool between two concurrent tasks [12]. The present study measured divided attention in terms of attentional resource capacity and allocation strategy in patients with mild head injury. Relation of these parameters of divided attention with behavioural sequelae was studied, in order to see whether divided attention deficits required compensatory effort leading to development of symptoms.

Materials and Method

Sample

Nineteen patients with history of concussive closed head injury of mild severity i.e. duration of unconsciousness less than 6 hrs in the age range of 20-45 yrs. (mean age 34.2 yrs S.D. 8.4 yrs); with a minimum of 5 yrs of schooling (mean education of 12 yrs of schooling, S.D. 4 yrs) formed the patient group. Duration after injury was between 3 months to 1 year. Duration of unconsciousness following head trauma ranged from transient to five and half hours with a mean of 80 minutes. None of the patients had history of multiple head injury, post traumatic epilepsy, psychiatric disorders or neurologic disorders other than post concussion syndrome. Clinical examination found no neurologial deficits or deficits of vision and hearing. Symptoms of patients could not be attributed to interpersonal stressors and were consequent to the head injury. Nineteen normal volunteers with no history of psychiatric or neurological disorders, with similar age and education formed the control group. In normals mean age was 32 yrs, S.D. 7.6 yrs; mean education was 12.4 yrs of schooling; S.D. 3.4 yrs. Patients and normals did not differ significantly in age and education. 17 subjects in each group were males.

Procedure

Divided attention was assessed in dual task paradigm. Two sets of dual tasks were used which varied in the degree of overlap of resources pools between the tasks.

Dual task paradigm I:

The two tasks utilized resources from different hemispheres or processing structures. Task A consisted of the identification of the non-member in a triad of words, which being a verbal task tapped left hemisphere attentional resource. Task B, the concurrent task, was identification of change in rhythm, being a musical task required right hemisphere attentional resource. The two tasks therefore did not tap the same attentional pool; consequently there was no overlap in attentional resources. Task A consisted of 100 sets of triads of common Kannada words. There were 2-4 letters per word. Words were arranged in 3 rows in the center of a 13 cms × 11 cms card. Distance between rows was one cm. In each triad, two words belonged to the same category and one word did not belong to that category, i.e was a non-member of the triad. There were eleven categories. The non-member word randomly occurred in the top, middle and bottom row 34, 33 and 33 times respectively. Each card was presented tachistopically for 4 seconds with an intertrial interval of 2 secs. Subject called out the non-member word on each trial. Task B consisted of auditory presentation of pre recorded of auditory presentation of pre-recorded rhythm beats. The rhythms were composed by simple hand beats on a plane surface, with a total of 124 changes in the rhythm of the beats. Subject pressed a tally counter with the left hand whenever the beat changed. Each task lasted for 10 minutes.

Dual task paradigm II:

The two tasks utilized resources from the same hemisphere or processing resource. Task C consisted of identification of category words. Being a verbal task, it tapped the left hemispheric processing resource. 200 common 2-4 letter Kannada words were selected. 44 words belonged to three categories, i.e names of places (16 words), languages (15 words) and vegetables (13 words). These were randomly mixed with 156 filler words, which did not belong to the above three categories. Each word was printed in the centre of a 13 × 16 cm card which was presented tachistopically for 2 seconds with an inter trial interval of 1 second. Subject was required to read the word aloud if it belonged to one of the three aforesaid categories, if not say "No". Task D consisted of error detection in a number series. Numbers which were serial additions by two were presented auditorily in Kannada. The series did not exceed two digits and had random errors. Subject pressed a tally counter with the right hand whenever an error occurred.

The tasks, were administered singly to 3 normals at 100%, 75%, 50% and 25% levels of attentional allocations. Performance resources function revealed, that performance improved as resource investment increased, indicating that the tasks were not data limited. Each of the four tasks A, B, C, D were administered as a single task at 100% levels of resource allocation, i.e. the entire attentional resource was invested in the task. Within each dual task paradigm, the two tasks were administered at three levels of attentional resource allocation between the two tasks, i.e 75%-25%, 50%-50% and 25%-75%. Order of the two paradigms was counterbalanced across the subjects within each group.

Scoring

Number of correct responses on each task was noted. Performance Operating Characteristic (POC) was plotted for each paradigm for each subject. The POC is obtained by plotting performance on the two tasks at different levels of relative emphasis on the tasks, obtained by means of instructions. Limiting case of uneven emphasis is the single task performance level of the two tasks [13]. Raw scores were converted into percentages and then to angular transformed scores to normalize the distribution. Range of angular transformed scores is 0-9. Scores corresponding to 100% allocation were plotted on X and Y axis for the two task, other 3 points were also plotted to derive the POC curve.

Behavioural sequelae:

was measured using the Neuro behavioural rating scale [14]. It is a semistructured interview with 27 items which have loadings on cognition/energy, metacognition (knowledge of one's own cognitive process), somatic concern and language. The items are rated on a 7 point scale ranging from 'Not Present' to 'Extremely severe'. Ratings are based on interview of patient, informant and observation during the session. Maximum possible score is 162.

Results

Capacity of attentional resource was reflected in the accuracy of performance at 100% level of resource allocation. Performance of the two groups on the four tasks is shown in Table I.

Table I - Mean and SD on the four tasks given singly at 100% level of resource allocation

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Note: Standard deviations are given in brackets. All the t values were significant at <0.01 level.

In each of the 4 tasks, performance of patients was significantly poorer than that of normals indicating that capacity of attentional resources is lesser in patients. Presence of division of attention was assessed by comparing accuracy of performance across the 4 levels of attentional allocation for each of the tasks (Table II). One-way ANOVA found the main effect of level of attentional resource allocation to be significant in both groups. Inspection of means reveals that there was a significant drop in performance as attentional resource depleted in both groups. Depletion occurs because of allocation of resource to the concurrent task, indicating that division of attention has occurred in both groups.

Table II - Mean and SD on the four tasks in dual task condition at four levels of resource allocation in both groups.

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Efficiency of division of attention was assessed using the efficiency index EI. It is the distance of a point on the POC curve from the origin of the POC [12]. As maximum resource sharing between two tasks occurs at the 50%-50% level of attentional resource allocation, the distance from the origin of the POC to the point on the POC at this level of resource allocation was taken as the EI. It was calculated for each subject under each paradigm using the formula $EI=\sqrt{X^2+Y^2}$. The POC curves were non linear. Therefore attentional capacity i.e of 100% allocation plotted as the intercept would not affect the EI which is derived from the slope of the curve. Attentional capacity and attentional strategy are independently measured. Efficiency index in the 2 groups under the 2 paradigms is given in Table III.

Table III - Mean and SD of EI in paradigms I & II in both groups independently

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Note: SD is given in brackets

Two way ANOVA found the effect of group and paradigms to be significant with F values of 26.2 and 5.0 respectively. Interaction effect with and F value of 0.11 was non significant. Inspections of means revealed that in each paradigm the efficiency index of patients was lesser than that of normals. The E.I. of both groups is better on paradigm 1 as compared with that on paradigm 2. Efficiency of division of attention is superior in normals, as well as when the resources pools tapped by the 2 tasks do not overlap.

In the patient group symptoms following head injury were in terms of inability to concentrate, forgetting recent events, headache, worry about the future, fatiguability, irritability, inability to withstand noise, retarded movements and sadness of varying degrees. Mean ratings on different items of the neurobehavioural rating scale is depicted in Table IV.

Table IV - Mean ratings for patients on the neurobehavioural rating scale

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Note: Mean ratings were 0 on items not shown in the table.

Association between efficiency of division of attention and severity of symptoms was examined. Product moment correlation was computed between mean ratings and EI of each paradigm. The correlation were 0.15 and 0.18 for paradigms I and II respectively which were non significant.

Discussion

Attentional resource capacity is reduced in patients. Irrespective of the attentional in patients. Irrespective of the attentional pool i.e. left hemisphere resource pool or the right hemisphere resource pool this capacity reduction is present. The generalized effect could be attributed to the pathophysiology of head injury. Even mild head injury is associated with diffuse axonal shearing [15]. Disconnections in neural networks resulting from this could result in cognitive deficits [16]. Depletion of attentional resources may be another outcome of widespread disconnection in the brain. Division of attention is present in patients. However the strategy of attentional allocation in dual task is not efficient.

Reduced efficiency seems to be present even when attentional demands do not overlap. This indicates that the strategy of allocation is not optimal in parents. Combined with the reduced attentional capacity in patients, the picture which emerges is that even mild head injury results in depleted attentional resources, but sufficient resources are present for division of attention to occur. However sub optimal strategies of division are employed. This leads to a situation wherein the patient is doubly handicapped in divided attention situations. The dual handicap is the depletion of resources and suboptimal strategies of division which are acting independently. As the patients are able to divide attention despite the double handicap, it would require compensatory effort. When compensatory effort has been present chronically it is known to act as stressor and lead to the development of symptoms [1], [5]. In this case there is no correlation between severity of symptoms and deficiency of attentional strategies. The range of symptom severity was restricted and sample size was small, which may explain the lack of correlation. Lack of this correlation puts forth another hypothesis i.e., chronic compensatory effort may act as a stressor when primary deficits of information processing have to be compensated. By primary is meant the stages of stimulus registration and serial sequential processing under time pressure as in the PASAT [1] or recognition threshold experiment of serial stimulus processing [2]. Deficits at this level would demand a continuous and sustained effort as these processes are continuously involved in everyday life. Situations demanding division of attention are intermittent, in everyday life, hence the compensatory effort is not required to be continuous and sustained. Consequently this compensatory effort may not be so stressful hence is unrelated to the development of symptoms. Further studies are required to differentiate the effects of continuous and intermittent compensatory effort on the development of symptoms.

Acknowledgement

We are grateful to the Department of Neurosurgery, NIMHANS for their help in the selection of patients for the study.

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