Information processing following mild head injury


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Abstract

Research has shown that individuals who have sustained mild head injury demonstrate a slowed speed of processing that is exacerbated by fatigue/stress. We administered the Paced Auditory Serial Addition Test (PASAT) at the beginning and at the end of a 4-h experimental protocol to determine whether fatigue or a stressor would result in poorer scores for individuals who had previously sustained mild head injury. A significant improvement was found between the first and second administration for both head-injured and control subjects, but difference scores revealed a significant between-groups difference for the first of the four trials, with the head-injured participants performing worse than controls. Apparently, head-injured participants were slower to develop, as well as slower to regain, a means of efficiently processing rapidly presented information.

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Attentional deficits and reduced speed of information processing have been consistently found in mild head injury, despite lack of gross deficits in intelligence or memory (Bohnen, Jolles, Twijnstra, Mellink, & Wijnen, 1995). Moreover, these deficits are often the most persisting cognitive complaints (Chan, 2001). Head injury typically results in diffuse damage that produces a reduction in information processing capacity. This processing capacity has been broadly described as the number of operations the brain can carry out at the same time. Individuals with mild head injury demonstrate problems when they are required to analyze or process more information than they can handle simultaneously (Gronwall, 1989). Decreased information processing has been posited to be primarily due to problems with attention (Kay, Newman, Cavallo, Ezrachi, & Resnick, 1992; Szymanski & Linn, 1992). Research conducted by Ponsford and Kinsella (1992) demonstrated that the difficulty in performing a sustained attention task experienced by individuals who have incurred a mild head injury may result more from a slowed speed of processing than from attentional deficits. Whereas speed of performance is reduced for head-injured participants, no significant reduction exists in terms of accuracy of performance (Stuss et al., 1985). Further, fatigue and/or stress have been shown to further
compromise the processing speed of those who have incurred a mild head injury (Ewing, McCarthy, Gronwall, & Wrightson, 1980; Wood, Novack, & Long, 1984).

Studies over the years have made use of the Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977) to examine attentional ability, concentration ability, and speed of information processing in a mildly head injured population (Cicerone & Azulay, 2002; Gronwall & Sampson, 1974; King, 1996; Ponsford & Kinsella, 1992; Webbe & Ochs, 2003). It is interesting that the PASAT, due to its standing as a highly sensitive measure, has recently been used in a variety of conditions, including multiple sclerosis (Aupperle, Beatty, Shelton, & Gontkovsky, 2002; Fisk & Archibald, 2001; Shawarun, Schiaffino, LaRocca, & Johnston, 2002) and lupus (Shucard et al., 2004). While there has been a long history of using the PASAT to study mild head injury, however, there has also been evidence that the PASAT does not differentiate between mild head injury patients and normal controls (Fos, Greve, South, Mathias, & Benefield, 2000), suggesting that further study of this instrument is warranted.

In the present study, the PASAT was administered at the beginning and at the end of a 4-h experimental protocol to determine whether an extended period of participation in neurocognitive testing and the completion of complex survey forms, thought to result in a mild level of fatigue or stress, would result in decline of PASAT scores for mildly head-injured participants.

1. Methods

1.1. Participants

In this study, participants were 127 undergraduate volunteers from a large Southern university. Participants were divided into two groups based on self-reported head injury status: the first group (n = 67) consisted of subjects who reported having sustained a head injury which resulted in either a brief loss of consciousness or a brief period of feeling dazed (HI). Of the HI subjects, 51 were dazed or had a loss of consciousness for less than 1 min. Eight lost consciousness for less than 10 min, four subjects less than 1 h, and four subjects experienced loss of consciousness for greater than 1 h and less than 11 h. The mean time since injury for the head-injured participants was 5 years. The second group (NHI; n = 60) consisted of subjects who denied having had a head injury or other neurologic event (see Table 1). Participation was voluntary and earned the students’ extra credit towards their grades in psychology courses.

1.2. Procedures

Study participants completed the PASAT twice, once at the beginning of a 4-h experimental protocol and again at the end. The measure was administered twice as a means of determining whether, and to what degree, a mild amount of fatigue would affect participants’ second set of PASAT scores. During the intervening time, participants completed several hours of neuropsychological testing and completion of survey forms and personality/emotional status testing.

2. Results

No significant differences were found between groups for PASAT total raw scores (Repeated Measures ANOVA: PASAT first administration: F = 1.40, p < .24; PASAT second administration: F = 0.27, p < .61). There was however a significant within subject effect for PASAT trial (PASAT first administration: F = 348.73, p < 0.0001; PASAT second administration: F = 572.14, p < 0.0001), with all subjects showing improvement across trials, in spite of the increased speed of presentation. There was no overall trial by group interaction (PASAT first administration: F = 0.83, p < 0.48; PASAT second administration: F = 1.93, p < 0.12). Planned comparison between groups paired t-tests for each trial, contrasting administration order (e.g., PASAT 1, trial 1 versus PASAT 2, trial 1) were performed (see Table 2). Significant

| Table 1 | Demographic information
<table>
<thead>
<tr>
<th>Age (mean) (years)</th>
<th>Gender (M/F)</th>
<th>Education (mean years in college)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI</td>
<td>21.10 (±5.1)</td>
<td>26/41</td>
</tr>
<tr>
<td>NHI</td>
<td>21.48 (±5.2)</td>
<td>12/48</td>
</tr>
</tbody>
</table>
administration differences were observed for all trials among NHI subjects but only for three of the four trials among HI subjects. There was no significant improvement among HI subjects for the most demanding speeded trial (1.2 s).

To examine the magnitude of practice effect differences noted above, difference scores were calculated between PASAT administrations, with a significant between-groups difference noted only for the first of the four PASAT trials ($F = 3.91, p < .05$). Even though the only significant difference was for the first trial, the head-injured subjects showed less of a practice effect than controls on all trials (see Table 3), and in no instances were the direction of the effects in the unexpected direction.

### 3. Discussion

These findings generally support those of previous studies which have found no significant deficits in accuracy of performance of head-injured participants when compared to non-head injured controls (Ponsford & Kinsella, 1992; Van Zomeren, Brouwer, & Deelman, 1984). In general, both groups improved on the second PASAT administration, which is consistent with research concerning the practice effects of the PASAT on normal young adult populations (Macciochchi, 1990). There, however, was no significant improvement among head-injured subjects for the most demanding speeded trial. This suggests that the demands of the last trial are so great that the head-injured subjects may not be able to compensate for that increased speed demand, despite the benefit of practice effects. This is similar to the results of Ewing et al. (1980) who found that mildly head-injured students were significantly poorer than normal controls on the PASAT when mildly hypoxic. The investigators postulated that the mild head injury resulted in residual damage that caused an impaired ability to withstand another central nervous system stressor.

Moreover, head-injured subjects showed less absolute improvement due to practice effects than non-head injured subjects when difference scores were compared. Significant differences existed between groups for the first trial of each PASAT presentation, with the head-injured participants performing worse than their non-injured counterparts. Even though the only significant difference was for the first trial, the head-injured subjects showed less of a practice effect than controls on all trials. Thus, it appears that head-injured participants were slower to regain a means of efficiently processing rapidly presented information.

In conclusion, while both head injured and non-head injured subjects showed improvement on the second administration of the PASAT, head-injured participants demonstrated a lower degree of practice effect, suggesting that they were susceptible to the effects of fatigue of a 4-h testing session. It appears that the head-injured subjects may have
subtle residual cerebral dysfunction that precludes them from mustering the cognitive resources needed to overcome the increased demands of stressful situations.

References


