CONCUSSION: DOES INTELLIGENCE HELP?

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Concussed university students and similarly aged and injured non-student patients were compared on tests of information-processing rate, memory, vocabulary and language ability. On the first test after injury there was no difference between the groups on any measure. Information-processing rate initially improved more rapidly in the students, who were significantly faster than non-students midway through convalescence. This lead was not maintained. Neither the number of days from injury until recovery, nor the level of final processing rate was significantly different from non-student controls. However, after recovery university students had significantly higher vocabulary scores (mean increase 17 IQ points) and higher word-fluency scores. Implications for the mechanism of concussion and the relevance of pre-morbid intelligence are discussed.

Ever since medical writers began documenting the effects of closed head injury there have been reports of apparently similar injuries having different effects in different individuals. In the sixteenth century Ambroise Paré could attribute this primarily to an act of God (Tower, 1966), but in recent times the blame has been placed on rather more material forces. It is now accepted that, as Symonds (1937) has said, "it is not only the injury that matters, but the kind of head". Although this maxim does not explain *why* some people should take longer than others to recover from concussion, it has at least stimulated investigation of contributing factors.

Thus there is now evidence that some 'kinds of heads' do have more adverse reactions to brain trauma than others. For example, the probability of full recovery and return to former occupations is smaller for elderly patients (Heiskanen and Sipponen, 1970) and for those with a history of psychiatric illness (Symonds and Russell, 1943), and the recovery period is longer if the patient has been concussed previously (Gronwall and Wrightson, 1975).

Similarly, it is frequently suggested that differences in intellectual ability produce differences in reaction to concussion (Walker, Caveness and Critchley, 1969), although there are two opposing views of the directions these differences will take. The first suggests that the more intelligent the individual, the less he will be affected by head injury, using the analogy that brain cell deterioration with age is less apparent in intellectuals. In contrast, the other view supposes that the more intelligent the person, the more he will be affected. Thus Critchley asks "Are such brains, by reason of their sheer efficiency, more vulnerable to the effects of blunt traumata, even of a minor sort?" (Critchley, 1969, p. 6).

Only anecdotal evidence has been published in support of each alternative. However, it is now possible to measure the degree of impairment caused by even minor injury, and thus to measure the time period before normal functioning returns, using tasks of information processing rate (Gronwall and Sampson, 1974; Gronwall and Wrightson, 1974). The purpose of this paper is to examine the consequences of concussion in patients of different IQ levels to see if those with higher intellectual ability do show greater or less reduction in channel capacity, and do recover before or after those with lower IQs.

METHOD

Subjects

From a pool of 271 cases on whom complete data had been collected as part of a larger research programme, the 12 who were university students were selected as the higher than average IQ sample. Of these, nine could be matched with non-student patients who had had similar accidents and injuries, but were from relatively unskilled occupations. The seven criteria used for matching the non-student/student pairs were: Age (± one year), Sex, Duration of unconsciousness, Duration of post traumatic amnesia (PTA), Type of accident, Condition on arrival at hospital, Days after injury before first test data were recorded (± one day).

All subjects were males aged between 18 and 31 years (student mean 21.2 years; non-student 21.1). Duration of PTA ranged from 10 minutes to 12 days in the matched pairs, thus cases ranged from very mildly to very seriously concussed. Only one of the non-student patients, a clerk who had left school after the fifth form, was a white-collar worker.

Materials and procedure

The paced auditory serial addition test (PASAT) was used to measure information processing ability. The subject listens to a taped series of 61 single digits (1-9 in random order) and is instructed to add each number he hears to the one just before it, and to give his answer aloud. Trials are given at four different speeds, starting with one digit every 2.4 secs and increasing by 0.4-sec steps each trial until at the fastest one digit is heard every 1.2 secs. Instructions and procedure were those reported in earlier investigations of PASAT performance after concussion (Gronwall and Wrightson, 1974; 1975).

As soon as the patient had recovered from the confused, disoriented stage after injury he was given PASAT, the Wechsler Memory Scale (Wechsler, 1945), and one form of the Quick-test (Ammons and Ammons, 1962). The four PASAT trials were interspersed with four trials of a word fluency test, using a modified version of Borkowski, Benton and Spreen's (1967) procedure. The patient had 60 seconds to say as many words as possible beginning with a specified letter. Two of the letters (e.g. MPTS) had high association value (AV) and two had low AV (e.g. KQVY), as reported by Borkowski, Benton and Spreen (1967).

PASAT and the word fluency test were repeated at approximately weekly intervals until PASAT scores had reached normal levels. Because of differences in severity of injury among the patients, and thus differences in recovery times, all pairs did not have the same number of PASAT tests. Only three PASAT measures were used to make group comparisons of progress during recovery. These were (i) the first test after admission to hospital, (ii) the mid-way test, i.e. the test on the day nearest to mid-way between the day of the accident and the day normal PASAT scores were recorded, and (iii) the number of days after injury before PASAT scores were normal.

After recovery each patient was retested with a different form of the Quick-test.

RESULTS

PASAT

Mean percentages correct for the student and non-student groups at each pacing rate are shown in Figure 1. The mean time taken for each correct response was averaged over the four trials for each subject, and the Walsh test (Siegel, 1965) used to compare the matched groups at each stage. No significant difference was found between students and non-students on the first test after concussion, but students were significantly better ($p<.05$) at the mid-way test.

However, students' scores did not return to normal any earlier than non-students'. Recovery times were not significantly different in the two groups (student mean 43.6 days; non-student 46.4).

Word fluency

Table 1 gives mean number of words per minute for high and low AV letters at the first test and after recovery. There were no significant differences between students and non-students immediately after injury. However, students produced significantly more words than non-students at the test where PASAT scores were in the normal range (high AV $p<.05$; low AV $p<.01$).

TABLE 1
Mean number of words per minute given by students and non-students after concussion and after recovery

	High AV letters		Low AV letters	
	First test	Recovery	First test	Recovery
Students	9.4	17.2	5.7	9.3
Non-students	7.7	12.7	3.4	6.3
Walsh test	NS	$p<.05$	NS	$p<.01$

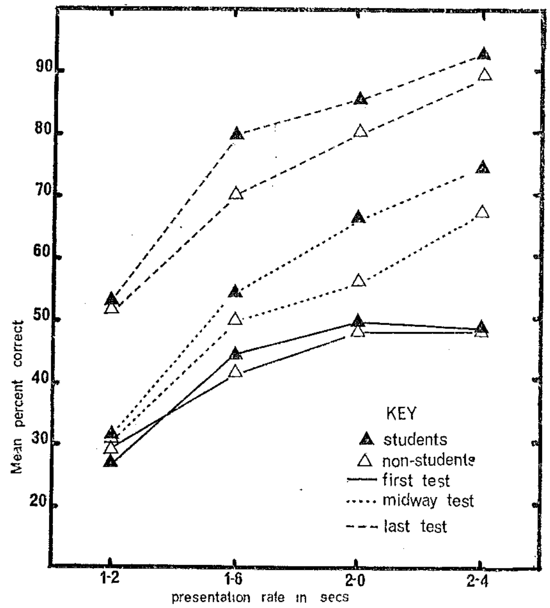

Figure 1. Mean percent correct PASAT at each pacing rate gained by students and non-students.

Quick-test and Wechsler Memory Scale

Mean Quick-test IQs and Wechsler Memory Quotients (MQs) for the two groups are shown in Figure 2. Neither Quick-test IQs nor MQs were significantly higher among students on the first test. However, as with word fluency results, students had significantly higher vocabulary IQs when retested after PASAT scores had recovered. All patients in both groups had improved Quick-test scores at this stage, but the amount of improvement was significantly greater among students, who increased their mean IQ by 16.5 points, while non-students improved by only 5.8 IQ points.

DISCUSSION

Investigations into the effects of mild and moderate concussion have consistently shown that information processing rate is reduced for some time after injury (Gronwall and Sampson, 1974; Gronwall and Wrightson, 1974) and that this reduction is associated with post-concussional complaints such as concentration problems, fatigue, and inability to carry on normal work (Gronwall and Wrightson, 1974). If differences in intellectual ability do produce differences in reaction to concussion, the two groups examined in this paper should have shown differences in the degree of reduction in processing rate, and/or differences in time before normal functioning returned. No such differences were found.

The only significant difference on PASAT tests was that students were significantly better than non-students mid-way through the recovery period. Possibly this occurred because more intelligent patients, when they have recovered to some extent, are able to incorporate different strategies to compensate for reduced processing efficiency. However, if this was so, it did not enable students to perform at a normal level any earlier than the matched non-student patients.

On the basis of pathological and neurophysiological data it has been suggested that concussion-producing injury reduces processing capacity because of reduced reticular formation activation of cortical areas (Gronwall and Sampson, 1974). From PASAT results it would appear that the extent and duration of this effect is unrelated to pre-morbid intelligence levels, and that there is no support for the notion that inelligence may be a factor which influences response to, or recovery from, head trauma.

However, on the other, largely verbal, tests there were consistent differences between the two groups. Head injury appeared to have a levelling effect on the vocabulary of higher IQ patients, and they were unable to produce or to recognize significantly more words than the average IQ sample.

This is not the result that would have been predicted. If retrieval from vocabulary store becomes less efficient because of reduced processing efficiency, both groups should have had proportionate reductions in scores on the language tasks, but the relative difference between them should have remained the same. This expected effect of vocabulary size was found in the differences between high and low AV letters on the word fluency test. In both groups roughly twice as many words beginning with high AV letters were given on the first test. After

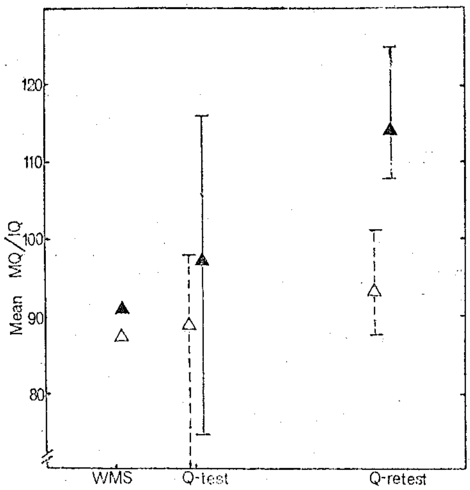

Figure 2. Mean first test Wechsler Memory Quotients and Quick-test IQs at the first test and after recovery, for students (solid triangles) and non-students (open triangles). Bars show range of IQs.

recovery the total number of words had significantly increased, but the proportion of responses to high and low AV letters remained approximately 2:1.

Why, then, did higher pre-morbid vocabularies not enable students to gain higher scores than non-students immediately after concussion? One possibility is that access to the enriched vocabulary of the higher IQ group could be more dependent on efficient cortical functioning than is access to the average vocabulary of the non-students. It is reasonable to suppose that retrieval of linguistic material will be a function of previous retrievals, since words are remembered more easily than nonsense syllables, and sentences more easily than lists of random words (Miller and Selfridge, 1950). Possibly the responses given by all patients immediately after concussion were from the most readily retrieved class, that is, from the ordinary basic vocabulary used in ordinary daily living activities. This basic vocabulary would not be expected to differ among members of the same society, and thus students and non-students did not produce different numbers of words.

There is other evidence that "functional" language is relatively impervious to closed head trauma. Heilman, Safran and Geschwind (1971) found only 15 cases of aphasia in a consecutive series of 750 head injury patients, and note that even this low percentage is probably inflated, since six of their aphasics had a history of prolonged alcohol abuse.

However, there is another factor which could also have contributed to the students' poorer performance. This is the natural anxiety generated by fears of possibly permanent brain damage. Obviously this aspect of concussion will be more important to someone who works with his brain than to a manual worker. When a university student finds he has difficulty with a relatively simple task such as word fluency, which he could have managed easily before his accident, it is quite probable there would be an anxiety reaction which would depress his scores even further.

In conclusion, it seems that although intellectual level does not appear to be a factor influencing length of time to recover from a closed head injury, patients with higher IQs do appear to be more handicapped than patients of average intelligence during this recovery period.

Based on paper presented to the Annual Conference of New Zealand Psychological Society at Wellington in August, 1975. This research was supported by the Medical Research Council of New Zealand and the New Zealand Neurological Foundation.

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