Performance on tests of frontal lobe function reflect general intellectual ability

M.C. Obonsawin a,∗, J.R. Crawford b, J. Page b, P. Chalmers b, R. Cochrane b, G. Low b

a Department of Psychology, University of Strathclyde, 40 George Street, Glasgow G1 1QE, UK
b Department of Psychology, University of Aberdeen, Aberdeen AB2 2UB, UK

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Abstract
Recent studies have indicated that performance on tests of frontal lobe function are highly associated with general intellectual ability (g).

Some authors have even claimed that the available evidence does not support a more specific account of frontal lobe function than to provide a general intellectual function for the performance of goal directed tasks. We examined the relationship between performance on the WAIS-R (as a measure of g) and performance on standard tests of frontal lobe function in 123 healthy individuals. Our results demonstrate that in healthy individuals (i) performance on the most popular tests of frontal lobe function shares significant variance, and (ii) a large proportion of that shared variance is highly associated with performance on the Wechsler Adult Intelligence Scales-Revised (WAIS-R), so that the tests are similar to the extent that they measure g. Performance on the Modified Card Sorting Test (MCST), however, is not related to g. The results support the claim that many tests of frontal lobe function measure primarily a non-specific intellectual function but also indicate that some tests, like the MCST, may be assessing more specific cognitive operations. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: General intellectual ability (g); Intelligence; Frontal lobe function

1. Introduction

Although there are many neuropsychological tests currently in clinical use that appear to be sensitive to frontal lobe dysfunction, there is no consensus as to the psychological functions these tests are measuring. Neuropsychological tests of frontal lobe function are said to measure many apparently different functions, including inhibition of automatic responses, spontaneity, perseveration, planning, attention, monitoring, fluency, and abstract reasoning. A number of investigators have attempted to make sense of the wide range of behavioural disturbances following damage to the frontal lobes, and each investigator appears to have emphasised discrete aspects of these disturbances. Many authors have suggested that the frontal lobes carry out the functions associated with working memory, and allow behaviour to be regulated by internal representations of the external world. Goldman-Rakic [19], Passingham [46], and Petrides [48], e.g. have all suggested different mechanisms for ways in which the frontal lobes could mediate the functions of working memory. The inability of individuals with lesions to the frontal lobes to use internal representation to guide behaviour was vividly described by Lhermite [31]. Fuster [17] emphasised the role of the frontal lobes in the control of sequential behaviours over time. Other investigators have suggested that the role of the frontal lobes is to select the response that is most appropriate for the current context, but the basis on which the frontal lobes makes the selection appears unclear. Passingham [45], e.g. has suggested that the frontal lobes select behaviours during the performance of a novel task, but contribute to behaviour much less when the task is well rehearsed. Nauta [38] wrote that frontal systems selected the appropriate response by assessing the information from the external and internal environments. More recently, Damasio [9] has stressed the importance of cues from the internal environment, by suggesting that the emotional response to a situation guides the selection of appropriate behaviours. Individuals who, for some reason, do not produce an emotional response to what is usually considered an emotional situation, often select an inappropriate behaviour. According to Damasio, the ventromedial frontal lobe is necessary to guide behaviour selection on the basis of an emotional response [9].

Some investigators have suggested roles that appear to be less precisely defined than the roles mentioned above. Luria [32] wrote that the frontal lobes were responsible for
the planning, coordination and monitoring of behaviour. The notion of the frontal lobes having an “executive” function has grown steadily over the past few years, but this notion remains poorly defined. Shallice [52] has proposed that the frontal lobes control and supervise the allocation of attention, and thus, control the production of behaviour. Many of these theories of frontal lobe function are not mutually incompatible, and it is not unlikely that all these theories emphasise different functions, or component operations, carried out by the frontal lobes. Despite the variety of opinions on the role of the frontal lobes in the regulation of behaviour, there is some agreement that the different areas of the frontal lobes carry out separate component operations. There have been many attempts to parse and define these component operations. Some investigators have used correlations to parse out the shared cognitive components of different tasks. The rationale underlying the use of correlations is that if two or more tasks are correlated, the shared variance could be due to shared cognitive operations that is required to successfully complete the tasks. Perret [47] used this method to investigate the shared cognitive operations in the Stroop test and the verbal fluency task. On the basis of a modest correlation between the scores on the two tests, he concluded that both tests shared at least one cognitive operation. He suggested that both tasks required the inhibition of automatic responses. However, Perret’s results are difficult to interpret. It is not uncommon for scores on different tests to correlate and Spearman [55] showed that to some extent, performance on all tasks correlate, and an individual who performs well on one task will likely perform well on another task, whether they share a cognitive operation or not. Spearman went on to claim that tasks that intercorrelate do so because they measure a non-specific general intellectual ability or g [55]. Intellectual ability is not a cognitive operation, but a non-specific factor that affects the performance of most tasks. There is strong evidence that performance on many neuropsychological tests of frontal lobe function intercorrelate [5,8,14,29,44,54]. These intercorrelations could indicate shared cognitive operations, or they could indicate that tests of frontal lobe function are similar to the extent that they measure g.

The relationship between frontal lobe function and intellectual ability has puzzled investigators for many years. The influential work of Hebb and Penfield [23] and Tesber [58] appeared to make it quite clear that frontal lobe functions like planning and monitoring of behaviours could be severely impaired despite preserved intellectual ability. However, these conclusions were drawn on the basis of performance on the Wechsler intelligence scales. One approach to the measurement of intellectual ability that has received considerable attention distinguishes between the extent of accumulated knowledge (crystallised intelligence), and current ability (fluid intelligence) [24,25]. The Wechsler scales contain many subtests that assess crystallised over fluid intelligence, and tests of crystallised intelligence may not measure current intellectual ability in individuals with lesions of the frontal lobes. Indeed, Warrington et al. [60] reported that the scores on the Wechsler adult intelligence scale (WAIS) of individuals with unilateral parietal, temporal, occipital or frontal lobe damage were similar. Tests of fluid intelligence, however, may be more sensitive to frontal lobe dysfunction. Duncan et al. [12] demonstrated that individuals with lesions to the frontal lobes perform well on the Wechsler Adult Intelligence Scales-Revised (WAIS-R), yet present with lower g scores when g is measured by a test of fluid intelligence. According to Duncan et al. [12], not only is general intellectual ability an important factor influencing the performance on tests of frontal lobe function, but these tests measure frontal lobe function to the extent that they measure g. Consequently, neuropsychological tests of frontal lobe function should provide extremely good measures of g. Duncan [11] has argued that tests of frontal lobe function, and tests of general intellectual ability for healthy people, essentially test the ability to formulate the appropriate goal-directed behaviours in novel situations. In fact, Duncan et al. [13] have demonstrated that individuals with lesions to the frontal lobes are significantly impaired on a goal neglect task, that performance on the task is highly correlated with g, and that the performance of healthy individuals at the low end of the g distribution on the goal neglect task is similar to the performance of individuals with lesions to the frontal lobes.

The WAIS-R remains the most clinically popular test of intellectual ability. Lezak [30] has described it as the “workhorse of neuropsychological assessment”. Unlike individuals with lesions to the frontal lobes, healthy individuals show no discrepancy between scores on tests of crystallised and fluid intelligence, and scores on the WAIS-R provide an extremely good measure of g in the healthy population [28]. The relationship between the performance on the WAIS-R and performance on tasks of frontal lobe function remains to be explored in healthy individuals. We administered a battery of neuropsychological tests sensitive to frontal lobe dysfunction, along with the WAIS-R, to 123 healthy individuals. The neuropsychological tests chosen were tests that are often used to assess frontal lobe function. It is unlikely that performance on any of these tests is selectively sensitive to frontal lobe function [51], but it is likely that frontal lobe activity contributes substantially to the successful performance on these tests. On the basis of Duncan’s hypothesis that general intellectual ability consists mostly of those psychological functions that are usually associated with frontal lobe function [11], we predicted that performance on all tests of frontal function would share significant variance, and that a large proportion of that shared variance would be highly associated with performance on the WAIS-R.

2. Methods

2.1. Participants

Participants (n = 123) were recruited from the community and received an honorarium for their participation.
These tests is described briefly. Often used to measure frontal lobe function. Each one of administered a battery of neuropsychological tests that are the contributions of age. In addition, each participant was of intellectual ability can be examined independently from the non-age graded scores. In that way, the contributions on the W AIS-R is not the full scale IQ, but the sum of W AIS-R [61]. In all the correlations carried out, performance on verbal fluency is thought to reflect behavioural spontaneity, the ability to guide behaviour over the period of 1 min by a command, and strategy formation for retrieval [49]. Impairment on the task is associated with the lateral, or the inferior prefrontal region, especially of the left hemisphere [56].

Potential participants were excluded if they had ever been hospitalised for a mental illness, had ever had alcoholism, a serious head injury, a stroke or a neurological condition, or if they were currently receiving medical treatment for anxiety or depression. The demographic characteristics of the sample are shown in Tables 1–3, and are compared to the demographic characteristics of the population of Great Britain in the 1981 Census. The mean (±S.D.) age of the participants was 40.3 (±14.0) years, and ranged from 16 to 75 years. The definition of social class was based on occupation, as defined by the Office of Population Censuses and Surveys [42]. The social classes were: I (professional), II (managerial), III (skilled, non-manual and manual), IV (partly skilled) and V (unskilled). The number of years of education was calculated by adding the total number of years of full-time education, and allowing 0.25 year for each year of part-time education.

### 2.2. Procedure

Each participant was administered the full version of the W AIS-R [61]. In all the correlations carried out, performance on the W AIS-R is not the full scale IQ, but the sum of the non-age graded scores. In that way, the contributions of intellectual ability can be examined independently from the contributions of age. In addition, each participant was administered a battery of neuropsychological tests that are often used to measure frontal lobe function. Each one of these tests is described briefly.

#### 2.2.1. Verbal fluency

The controlled oral word association test (COWAT), or verbal fluency task, was administered as described by Benton and Hamsher [2,3] and Goodglass and Kaplan [20] to assess word generation (language and executive functions). The letters F, A and S were used, and participants were asked to generate as many words as possible for each letter. A duration of 60 s were allowed for each letter. The score is the total number of words correctly produced over the 3 min period. This task is thought by many to be very sensitive to frontal lobe dysfunction [43,58]. Performance on verbal fluency is thought to reflect behavioural spontaneity, the ability to guide behaviour over the period of 1 min by a command, and strategy formation for retrieval [49]. Impairment on the task is associated with the lateral, or the inferior prefrontal region, especially of the left hemisphere [56].

#### 2.2.2. Modified Card Sorting Test

The Modified Card Sorting Test (MCST) is thought to measure the ability to form concepts and to shift cognitive set. Like the COWAT, it is thought to assess the integrity of frontal lobe function [43]. Participants are required to sort cards according to specific dimensions (colour, number and shape), and to change the sorting rule on a cue provided by the examiner. It was administered and scored according to the method described by Nelson [39]. We chose the percent perseverative error score, which appears to be the score that is most sensitive to frontal lobe dysfunction. The test is said to assess behavioural flexibility, the ability to respond to environmental cues and feedback, and conceptual and abstract function. The locus of impairment is still unresolved, but the superior dorsolateral frontal cortex, perhaps Brodmann’s area 9, especially in the left hemisphere, has been suggested for the Wisconsin Card Sorting Test [33–35,57].

#### 2.2.3. The Stroop test

The Stroop test, we used the interference score, because it is this score that is thought to be sensitive to frontal lobe dysfunction. The Stroop test is thought to measure impaired response inhibition and attention. Whereas there is general agreement that lesions to the frontal lobes impair performance on this task, there is no agreement as to whether lesions to the left [47] or right [59] hemispheres cause greater impairment.

#### 2.2.4. Tower of London

The Tower of London (TOL) is a modification by Shallice [52] of the Tower of Hanoi. The total score was calculated in the manner suggested by Shallice. The TOL is thought to measure strategy generation, planning and anticipatory processing (lookahead). It is thought to be sensitive to lesions of the left frontal lobe.

#### 2.2.5. Cognitive estimation

The cognitive estimates test, thought to measure strategy planning, requires that the participant verbally answer 10

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### Table 1

<table>
<thead>
<tr>
<th>Social class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>43</td>
<td>12</td>
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<td>48</td>
<td>19</td>
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### Table 2

<table>
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<th>Age</th>
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<td>18</td>
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<tr>
<td>&gt;60</td>
<td>Female</td>
<td>47</td>
<td>48</td>
<td>32</td>
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</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Performance on WAIS-R and years of education of participants</th>
<th>Mean (S.D.)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIQ</td>
<td>104.00 (14.06)</td>
<td>68–140</td>
</tr>
<tr>
<td>VIQ</td>
<td>105.72 (14.06)</td>
<td>72–143</td>
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<tr>
<td>FSIQ</td>
<td>105.35 (14.06)</td>
<td>70–141</td>
</tr>
<tr>
<td>Education</td>
<td>12.84 (2.77)</td>
<td>8–20</td>
</tr>
</tbody>
</table>
questions. More than likely, the participant will not know the exact answer to the question, but has to provide the best guess possible. The scoring system attempts to quantify the extent to which the participant’s score deviates from the norm. For example, they could be asked what is the height of a double decker bus. We used a 10 question version described by Shoqiet et al. [54] and investigated more intensively by O’Carroll et al. [41]. This version was adapted from the original version by Shallyce and Evans [53]. The test is said to be sensitive to lesions in the right and left frontal lobes [53].

2.2.6. Paced auditory serial addition task (PASAT)

Although not usually considered as strictly a test of frontal lobe function, PASAT is sensitive to problems with attention and working memory, functions usually associated with the frontal lobes. It was, therefore, included in the test battery. We used the original four-trial version of Gronwall and Wrightson [21], which has digits that are recorded at a rate of one every 2.4, 2.0, 1.6 and 1.2 s. The score used is the number of correct responses on all four trials. Performance on this task is known to be highly associated with the attention/concentration factor of the W AIS-R [7].

2.2.7. Uses for common objects

In the uses for common objects task, the participants are required to give as many uses as possible for two items: a bottle and a brick. They are given 3 min for each item. The score is the total number of correct items that they report. Repetitions, or uses that are thought to be too similar to a previous response, are not counted. Like the verbal fluency task, this task is thought to measure behavioural spontaneity and strategy planning. There is evidence that individuals with lesions to the frontal lobes are impaired on this task [6,62].

3. Results

The score chosen to summarise performance on the WAIS-R was the sum of the non-age graded subtests of the WAIS-R. The interference score of the Stroop test and the percent perseverative score on the MCST, both ratio scores, were transformed to their arc sin square root to build the Pearson correlation matrix. Many correlations were carried out, but no Bonferroni-type corrections to the significance level were applied, because the issue of interest was the number of significant correlations in the presence or absence of certain covariates. We did not dwell on nor emphasise any particular correlation.

Performance on all neuropsychological tests of frontal lobe function correlated significantly with performance on the WAIS-R. Although many of the tests are significantly correlated with one another, the correlations are not very high (Table 4). If correlations with scores on the WAIS-R are omitted, and only correlations involving the neuropsychological tests of frontal function are considered, we find 13 significant correlations, ranging between 0.2 to about 0.5. When the same correlation matrix is covered with performance on the WAIS-R, most correlations decrease and in fact, only four remain statistically significant (Table 5). Although scores on these neuropsychological tests are similar

Table 4

<table>
<thead>
<tr>
<th>WAIS-R</th>
<th>Tower</th>
<th>Estimates</th>
<th>Objects</th>
<th>Stroop</th>
<th>MCST</th>
<th>Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower</td>
<td>+0.3770</td>
<td>0.3027</td>
<td>0.3027</td>
<td>0.1864</td>
<td>+0.0701</td>
<td>0.1864</td>
</tr>
<tr>
<td>Estimates</td>
<td>−0.5764</td>
<td>0.1971</td>
<td>0.0971</td>
<td>0.1732</td>
<td>+0.0058</td>
<td>+0.2167</td>
</tr>
<tr>
<td>Objects</td>
<td>0.4816</td>
<td>0.2455</td>
<td>0.4816</td>
<td>0.0971</td>
<td>0.2455</td>
<td>0.2455</td>
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<tr>
<td>Stroop</td>
<td>+0.3816</td>
<td>0.1758</td>
<td>0.3816</td>
<td>0.0971</td>
<td>0.1758</td>
<td>0.1758</td>
</tr>
<tr>
<td>MCST</td>
<td>−0.2396</td>
<td>0.0156</td>
<td>0.2396</td>
<td>0.1402</td>
<td>−0.0156</td>
<td>0.1402</td>
</tr>
<tr>
<td>Fluency</td>
<td>+0.5313</td>
<td>0.2098</td>
<td>0.5313</td>
<td>0.0156</td>
<td>0.2098</td>
<td>0.2098</td>
</tr>
</tbody>
</table>

a Pearson r correlations in bold typeface are all significant at the 0.05 level.
b Interference score, arc sin square root transformation.
c Percent perseverative errors, arc sin square root transformation.

Table 5

<table>
<thead>
<tr>
<th>WAIS-R</th>
<th>Tower</th>
<th>Estimates</th>
<th>Objects</th>
<th>Stroop</th>
<th>MCST</th>
<th>Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower</td>
<td>+0.1541</td>
<td>0.0144</td>
<td>0.1541</td>
<td>0.0144</td>
<td>0.1541</td>
<td>0.1541</td>
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<tr>
<td>Estimates</td>
<td>+0.0970</td>
<td>0.0058</td>
<td>0.0970</td>
<td>0.0058</td>
<td>0.0970</td>
<td>0.0058</td>
</tr>
<tr>
<td>Objects</td>
<td>+0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
</tr>
<tr>
<td>Stroop</td>
<td>+0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
</tr>
<tr>
<td>MCST</td>
<td>+0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
<td>0.0970</td>
</tr>
<tr>
<td>Fluency</td>
<td>+0.3144</td>
<td>−0.1004</td>
<td>+0.3144</td>
<td>−0.1004</td>
<td>+0.3144</td>
<td>−0.1004</td>
</tr>
</tbody>
</table>

a Pearson r correlations in bold typeface are all significant at the 0.05 level.
b Interference score, arc sin square root transformation.
c Percent perseverative errors, arc sin square root transformation.
Correlations in bold typeface are all significant at the 0.05 level.

Table 7: Rotated factor matrix (Varimax rotation) from principal component analysis.

<table>
<thead>
<tr>
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<th>Factor 1</th>
<th>Factor 2</th>
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<tr>
<td>Tower</td>
<td>0.61</td>
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<tr>
<td>Estimates</td>
<td>-0.60</td>
<td>0.30</td>
</tr>
<tr>
<td>Stroop</td>
<td>0.54</td>
<td>0.05</td>
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<tr>
<td>MCST</td>
<td>-0.01</td>
<td>0.92</td>
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<tr>
<td>Fluency</td>
<td>0.75</td>
<td>-0.06</td>
</tr>
<tr>
<td>PASAT</td>
<td>0.78</td>
<td>-0.00</td>
</tr>
</tbody>
</table>

* Pearson r correlations in bold typeface are all significant at the 0.05 level.

Table 8: Pearson r correlations between performances on the WAIS-R (sum of scaled scores, before age-grading) and the factor scores for tests of frontal lobe function, in healthy participants (n = 123).

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
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<tbody>
<tr>
<td>PIQ</td>
<td>0.2775</td>
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</tr>
<tr>
<td>Stroop</td>
<td>0.151</td>
<td>-0.094</td>
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<td>MCST</td>
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<tr>
<td>Fluency</td>
<td>0.319</td>
<td>-0.016</td>
</tr>
<tr>
<td>PASAT</td>
<td>0.216</td>
<td>-0.005</td>
</tr>
</tbody>
</table>

* The significance value is provided below the r value. Pearson r correlations in bold typeface are all significant at the 0.05 level.

4. Discussion

Our results demonstrate that in the healthy population, general intellectual ability accounts for a large proportion of the shared variance between neuropsychological tests of frontal lobe function. General intellectual ability, therefore, contributes substantially to the performance on neuropsychological tests sensitive to frontal lobe dysfunction. The results also show that within the healthy population, there may be some variance, independent of general intellectual ability, in the more specific abilities required to complete some tests of frontal function. These results resemble those previously obtained by Duncan et al. [14], but the two studies are different in three main ways. The present study examined the performance of healthy individuals and not individuals with head injury, the sample size was much larger (123 as opposed to 24), and the test of intellectual function was the WAIS-R and the verbal scale is negative, reflecting the fact that the main component of factor 2 is the percent perseverative error score on the WCST, whereas the sums of the WAIS-R scales reflect the number of correct responses.
display some shared variance, but this shared variance was low. Not more than 25% of the variance was shared by these popular neuropsychological tests of frontal lobe function. These correlations found in healthy individuals are similar to correlations reported in studies examining individuals with lesions to the frontal lobes [5,8,29,54], or individuals with head injury [14], and the healthy elderly [44].

One explanation for the low correlations between the tests is that these tests have low specificity for frontal lobe functions, and that the contribution of frontal lobe activity to the performance of these tests is low. The shared variance between these tests could represent the variance due to the shared frontal functions. However, not only does the performance on most neuropsychological tests intercorrelate, but performance on all neuropsychological tests also correlate with performance on the WAIS-R. At least some of the variance in the performance of these tests can be accounted for by g. This result is not surprising, given that individuals who perform well on one test will also tend to perform well on other tests [55]. The more important issue to be resolved is whether the shared variance between individuals tests of frontal lobe function is the same variance that appears to be shared with g. Does g account for the shared variance between neuropsychological tests of frontal lobe function? The results of our study indicate that it might. When the correlation matrix of tests of neuropsychological function is co- varied with performance on the WAIS-R, but not age, most of the significant correlations between test scores disappear. Our results demonstrate clearly that general intellectual ability, and not age, is a major contributor to the shared variance between these tests. These results are similar to those previously reported by Duncan et al. [14], who found that partialling out the scores on a measure of fluid intelligence (the Culture Fair Test) reduced the correlations between performance scores on tests of frontal lobe function in 24 individuals with head injury.

In addition, six of the seven neuropsychological tests loaded highly on one factor. The score for this factor correlates extremely highly with performance on the WAIS-R. These results have two clear implications: (i) in healthy individuals, many of the most popular neuropsychological tests of frontal lobe function are similar to the extent that they measure g, and (ii) a battery of these tests provides a very good measure of g. These results are consistent with recent neuroimaging studies demonstrating the activation of restricted areas of the frontal lobes during the performance of tests of frontal lobe function [15], and tests of fluid intelligence [16,50].

These results emphasise the importance of considering more than two tests of neuropsychological function when using the correlational method to parse out shared cognitive components. Perrett [47], for example concluded that the shared variance between performance on the Stroop test and on verbal fluency was likely a shared specific cognitive component, which he hypothesised to be the inhibition of an automatic response. However, our results indicate that the shared variance between scores on verbal fluency and the Stroop test is also shared with scores on the Tower of London, PASAT, cognitive estimates, and uses for common objects, and with performance on the WAIS-R, so that it may be premature to speculate on the specific shared cognitive components that may be recruited to perform these tasks on the basis of shared variance. Intellectual ability is a non-specific and unsatisfactory explanation for the shared variation between tasks, but it does have the advantage of being a single, simple explanation for a considerable proportion of the variance, and any future attempt to account for intercorrelations between tasks of frontal lobe function by proposing more specific processes should first demonstrate that g alone does not account for the entire variance.

According to Duncan, it is precisely because these tests are related to general intellectual ability that they are sensitive to frontal lobe dysfunction. Duncan has argued that those skills long thought to be components of g (problem-solving, planning, control of behaviour under conditions of novelty) are also skills that are thought to be mediated by the frontal lobes. Duncan found that individuals with lesions to the frontal lobes showed a large discrepancy between scores on tests of crystallised intelligence (the WAIS-R) and scores on a test of fluid intelligence (Cattell’s Culture Fair Test). These individuals had high, and perhaps unaltered scores on the WAIS-R, but scores on the Culture Fair Test were much lower than predicted by their performance on the WAIS-R. Duncan argues that tests of frontal lobe function provide good measures of intellectual ability. Our results support Duncan’s interpretation. Six of the seven tests of frontal lobe function were similar to the extent that they measured general intellectual ability. Because the participants in our study were all healthy, there should be no discrepancy between scores on tests of crystallised and fluid intelligence, and scores on the WAIS-R should provide a good estimate of general intelligence.

In their brief historical review, Reitan and Wolfson [51] clearly demonstrate that the association between frontal lobe functions and general intelligence has a long history (relative to the history of neuropsychology). Early reports by Gelb and Goldstein [18] and Ackery [1] had suggested that frontal lobe lesions impaired intellectual function, as assessed by problem-solving tasks, and Brickner [4], Jefferson [26,27] and Halstead [22] later argued that the frontal lobes were the brain regions underlying intellectual function. Indeed, the wish to prevent emotional arousal interfering with intellectual function was part of the rationale for the prefrontal leucotomies performed by Moniz [36,37]. Reitan and Wolfson [51] argue that individuals with damage to the frontal lobes usually present with generalised impairment on tasks, in contrast to individuals with non-frontal pathology, who present with much more specific impairments. These authors argue that in the absence of better evidence, it is difficult to suggest more precise functions for the frontal lobes [51]. Our results provide some support for their argument by demonstrating that the shared variance in the performance on tests of frontal lobe function can be largely accounted for.
References


