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Strategy application disorder: the role of the frontal lobes in human multitasking

Received: 31 March 1999 / Accepted: 23 July 1999

Abstract Strategy application disorder is a term used to describe a pattern of deficits, usually associated with frontal lobe dysfunction, where people show disorganisation, absentmindedness and problems with planning and decision making in everyday life despite normal performance on traditional neuropsychological tests. It is argued that the prototypical situation which presents problems for these cases are those which require multitasking, and although good cases are rare in the literature, those that do exist show a characteristic neuropsychological pattern. Moreover, this pattern is confirmed in recent group studies of multitasking and of the relationship between multitasking tests (such as the Six Element Test), failures in everyday life and other neuropsychological measures. At present the evidence suggests that the potential frontal brain regions most implicated in multitasking are the anterior cingulate; B.A. 10 and immediately adjacent areas; and the right dorsolateral prefrontal cortex, with each making a unique contribution to different aspects of performance. Furthermore, recent studies show striking dissociations between performances on multitasking tests and two of the most commonly administered measures of executive function: the verbal fluency test and the Wisconsin Card Sorting Test, which sets a minimum level for a fractionation of the executive syndrome in humans.

Introduction

Deficits in purposive goal-directed behaviour associated with frontal lobe damage date back at least 150 years, to Harlow’s famous case Phineas Gage described as “devising many plans of future operation, which are no sooner arranged than they are abandoned in turn for others appearing more feasible” (Harlow, 1868). Gage’s problems were, however, part of a wider cluster of symptoms, which became known as the “frontal lobe syndrome”. Only recently has empirical evidence emerged that suggests that the functions of the frontal lobes (“executive functions”) may fractionate (e.g. Burgess & Shallice, 1996a, 1996b; Burgess, Alderman, Emslie, Evans & Wilson, 1998; Robbins, James, Owen, Sahakian, McInnes & Rabbitt, 1997).

Perhaps the most surprising findings related to this fractionation are those from single cases who show the circumscribed deficits termed the “strategy application disorder” (Shallice & Burgess, 1991; Goldstein, Bernard, Fenwick, Burgess & McNeil, 1993; Levine, Stuss, Milberg, Alexander, Schwartz & Macdonald, 1998). This is a pattern of problems which manifest themselves most in real-life complex situations which require the organisation and structuring of goal-related behaviour in situations with few external constraints. Prototypical situations of this kind in everyday life are those involving “multitasking”, such as shopping (Shallice & Burgess, 1991) or preparing a formal meal for many guests (see Penfield & Evans, 1935). That frontal lobe damage might cause impairments in these situations is perhaps not, prima facie, surprising since their very complexity might suggest that they require a great number of different cognitive resources any of which might be damaged in any one case. It is made surprising, however, by the fact that these cases may show their deficits not only in the context of unimpaired IQ, memory, language and visuo-perceptual functions, but even where performance on a wide range of “executive tests” known to be sensitive to frontal lobe damage is normal (Shallice & Burgess, 1991; Goldstein et al., 1993; Duncan, Burgess & Emslie, 1995; Eslinger & Damasio, 1985). Thus, these cases suggest that there may actually be a small set of processes which are critical to multitasking in humans: an activity which is at the very heart of competency in everyday life. The aim of the present paper is to outline how recent evidence from a number of sources suggests.
that it may soon be possible to isolate the cognitive and neuroanatomical systems which support multitasking.

**Empirical characteristics of patients with circumscribed multitasking deficits**

There are a number of recent case reports of patients with circumscribed multitasking deficits. By “circumscribed” it is meant that their disability in real-life situations involving multitasking was not reflected in their (largely intact) performance on clinical tests of neuropsychological functions which did not involve multitasking: a pattern referred to by Shallice and Burgess (1991) as the “strategy application disorder” (see also Goldstein et al., 1993). A summary of these cases is given in Table 1. None of these cases had any language or visuo-perceptual impairments and all scored within the superior range on tests of current general intellectual functions. Four of the seven cases showed no impairment on any memory test and two showed no impairment on a range of clinical executive function tests which are known to be sensitive to frontal lobe lesions.

Table 1, however, shows an interesting pattern in those cases who did fail an executive task. While there is no individual test which has been failed by even half the patients, there are some small hints at consistency, despite the fact that the tasks administered to each case differed. Thus, two cases each have failed Tower of Hanoi tasks, proverb interpretation, and the Self-Ordered Pointing Test. It remains to be seen if this pattern is meaningful or relates to an anatomical proximity artefact (Shallice, 1988). Whatever the reason, it is unlikely to reflect the frequency with which the tasks have been administered, since at least two tasks which have been administered to them all – the Wisconsin Card Sorting Test (WCST) and Verbal Fluency (VFT) tests – have been performed well by every case. This issue will be returned to later.

The unifying feature of all of these cases, however, is a marked impairment in everyday life. For instance, following his operation for excision of a bilateral frontal meningioma, EVR’s poor financial decisions led to bankruptcy, and he was unable to hold down a job (Saver & Damasio, 1991). Patients AP, DN, and PS also lost their jobs following their frontal lobe damage, with employers reporting tardiness and disorganisation with even simple tasks left unfinished. The other cases (FS, JD, and GL) maintained some gainful employment, but at a greatly reduced level, and with some difficulty. In the case of GL, this was despite 12 months of intensive rehabilitation (von Cramon & von Cramon, 1994). While not all cases show exactly the same problems in everyday life, there are some remarkable similarities. For instance, EVR is reported as taking hours to perform simple matters because of his indecisiveness: to go out to dinner required that he consider the seating plan, menu, atmosphere and management of each restaurant and he might even drive to see how busy each of them was, but still be unable to come to a decision. Consider now the description of JD by Goldstein et al. (1993): “He had difficulty making decisions, culminating in his taking 2 weeks to decide whether to use for a work presentation; the decision was never reached” (p. 274).

For other cases the most prominent feature is failure of prospective memory, which shows itself as an inability to follow time constraints, to meet deadlines or keep appointments. An additional feature that has been noticed many times in our laboratory but never fully quantified is that patients will sometimes be quite content to abandon a task even though it is clearly incomplete. This may be related to the set abandonment seen in frontal patients in more straightforward situations (Burgess & Shallice, 1996a). When this happens, the patients appear completely satisfied with what they have accomplished even when it is pointed out to them that the task is unfinished. We have never seen a control exhibit this behaviour.

To quantify these problems, Shallice and Burgess (1991) devised two tasks which were intended to make analogous demands to the situations in everyday life which present problems for these cases. The first was called the Multiple Errands Test (MET). This was a real-life task based around a shopping precinct. Three patients with a strategy application disorder, and a

<table>
<thead>
<tr>
<th>Measure</th>
<th>Intelligence</th>
<th>EVR Superior</th>
<th>AP Superior</th>
<th>DN Superior</th>
<th>FS Superior</th>
<th>JD Superior</th>
<th>GL Superior</th>
<th>DS Superior</th>
<th>PF Superior</th>
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<tr>
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<td>Tasks administered</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>12</td>
<td>6</td>
<td>2</td>
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<td>0</td>
<td>2</td>
<td>3</td>
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<td>0</td>
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<tr>
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<td>Task administered</td>
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<td>12</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>13</td>
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<tr>
<td>Task impaired</td>
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<td>0</td>
<td>SOP</td>
<td>SOP trails</td>
<td>Proverbs</td>
<td>ToH</td>
<td>20 Qs</td>
<td>Proverbs</td>
<td>ToH</td>
</tr>
</tbody>
</table>

a EVR (Eslinger & Damasio, 1985); AP, DN and FS (Shallice & Burgess, 1991); JD (Goldstein et al., 1993); GL (von Cramon & von Cramon, 1994); DS (Duncan et al., 1995); PF (Goel & Grafman, submitted)

b Tests vary
c WMS is counted as one test. Digit Span is not included. Where there are two forms of a test (e.g. immediate and delayed recall) this is counted as one test only
d Tests vary. Multitasking tests (e.g. the SET) are not included
e Self-Ordered Pointing Test of Petrides and Milner (1982)
f Trail-Making Test, letters & numbers (Reitan, 1958)
g Proverb Interpretation (e.g. Gorham, 1956)
h Tower of Hanoi (Simon, 1975)