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Right, left or both? Brain hemispheres and apraxia of naturalistic actions

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Neuropsychology allows us to see more clearly how brain processes are organized by looking at the way they fall apart. For example, a hundred years of research on brain-damaged individuals with deficits of higher-level motor abilities have shed light on the organization of normal motor abilities. A consistent finding has been the dominant role of the left hemisphere in motor control in right-handers. However, the recent paper of Hartmann *et al.* challenges this tradition by suggesting that both hemispheres can contribute to complex object and tool use.

In everyday life humans skilfully use a very large range of objects and tools. It has often been reported, though, that after left-brain damage the ability to use them can be dramatically reduced in right-handed individuals. The recent paper by Hartmann, Goldenberg, Daumüller and Hermsdörfer [1] seems to suggest that the right hemisphere can also contribute to successful tool use.

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Ideational apraxia as a left-brain-damage syndrome

Over the years, the specific deficit of object and tool use has been given different labels such as ideational apraxia [2,3], agnosia [4] or amnesia of object use [5], and conceptual apraxia [6], each corresponding to different accounts. However, all these readings of the deficit share the view that it is conceptual in nature. Recently, some patients have been described with dramatic difficulties in using objects in everyday activities but spared lexical semantic knowledge about them [7,8]. By contrast, patients with semantic impairment but spared object use have also been reported [9]. Taken together these observations suggest a relative independence of the action and semantic domains [10].

To distinguish it from a semantic deficit proper, it has been proposed that ideational apraxia might be due to a malfunctioning of the contention scheduling system (see Box 1), the object representation either triggering the incorrect schemas or being disconnected from action schemas when a goal-directed action is attempted [8,11]. In a functional imaging study in healthy volunteers, the

Box 1. A computational account of ideational apraxia

An alternative account of ideational apraxia is related to the action-selection model of Norman and Shallice [19], according to which two complementary processes operate in the selection and control of action:

(1) The Contention Scheduling System is engaged in the control of well-learned or simple actions, and provides the basic mechanism by which the flow of routine actions can be produced without conflicts occurring in performance. This is accomplished by activating relevant, and inhibiting irrelevant, action schemas at appropriate times. The precise time at which appropriately activated schemas are initiated is set by environmentally activated triggers.

(2) The Supervisory Attentional System, comes into play whenever conscious, attentional control is required and provides excitatory or inhibitory input to schemas in the contention scheduling.

In one study, Cooper and Shallice simulated in great detail in a computational model the scenario of a patient preparing instant coffee using utensils and ingredients available on a patient's breakfast tray [11]. When the activation from higher-level schemas was weak, several error types occur, some of which related to the sequential organization, and many of which concerned the misuse of objects and tools. More recently, Cooper [20] applied the same model to five multiple-object tasks and found that, when lesioned, the model produced errors similar to those made by ideational apraxic patients. These computational results lend support to the view that successful goal-directed and object-related actions are dependent on the interaction between the object and action-schema networks. They are also consistent with a view that ideational apraxia arises from a disturbance of object representations triggering action schemas.

key brain structure activated when right-handed individuals demonstrated the use of objects was in the left inferior parietal lobe (IPL) [12]. As pantomiming the use of visually presented objects predicts, and correlates well with, object use in apraxic patients [5,13], it was argued that a lesion of the left IPL might cause ideational apraxia. A common factor in all studies mentioned so far is the emphasis of the dominant role of the left hemisphere in praxis.

Naturalistic actions engage the whole brain

The paper by Hartmann *et al.* [1] suggests that this does not seem to be the whole story. They evaluated the ability of patients with either left- or right-hemisphere lesions to perform naturalistic actions involving technical equipment, such as fixing a cassette recorder and preparing coffee with a drip coffee machine. In addition, patients were given tasks that assessed their ability to solve multi-step mechanical (the Tower of London) and non-mechanical (the 'treasure box') problems, to retrieve from semantic memory the functions of tools, and to infer them from the structure of novel tools (see also [13]).

Both patient groups scored significantly worse than and spent twice as much time as healthy controls in carrying out the naturalistic actions. The accuracy in performing naturalistic actions was comparable in both patient groups, although left-brain-damaged (LBD) patients scored slightly lower than right-brain-damaged (RBD) patients. For all groups, inserting the batteries and the tape into the recorder was a more error-prone activity than making coffee with a drip coffee maker.

Patients' performance on these naturalistic tasks showed varying correlation with their performance on the other tasks depending on the side of the brain damage. RBD patients had more difficulties in dealing with multi-step tasks, such as the Tower of London or the 'treasure box', a test derived from the 'artificial fruit' test originally devised to investigate imitation in chimpanzees [14]. However, RBD patients' performance on tasks that required only one correct action to gain a full score on a trial was satisfactory. By contrast, LBD patients' performance on making coffee correlated with aphasia (they were all aphasic to varying degrees) and impaired semantic retrieval, but their performance on setting the cassette recorder correlated with that on the treasure-box task.

In conclusion, RBD patients encountered difficulties in multi-step sequencing, probably because of a lack of attentional resources necessary for integrating actions over time. However, RBD patients are expected to demonstrate the use of single objects correctly [13]. By contrast, LBD patients' failure in carrying out naturalistic actions might depend more on their impaired lexical–semantic knowledge of objects and tools. Hence, LBD patients are as likely to be impaired when using single objects as when they carry out naturalistic actions [5,8]. Taken together, these results suggested to the authors [1] that the main difference between single-object use and everyday activities involving technical equipment relies upon how easily the mechanical constraints of the latter can be inferred.

Finally, these results show that the impairments to an action-production system, which differ qualitatively depending on the hemisphere damaged, do not seem to have specific neural correlates within each hemisphere: a lesion analysis did not reveal a single cerebral localization dedicated to the ability of completing multi-step actions [1].

A limitation of resources?

The paper by Hartmann *et al.* is not the first to address the role of the right hemisphere in everyday activities. The widely acknowledged view of ideational apraxia as a left-hemisphere syndrome had previously been challenged by a series of studies conducted by Schwartz, Buxbaum and collaborators [15,16]. These authors found that patients with LBD, RBD, and closed head injury were impaired in carrying out naturalistic, multi-step actions, and they interpreted the patients' impairment as being due to limitations of attentional resources. Interestingly, the patients' scores on multi-step actions correlated with many cognitive tests, including those sensitive to parietal lesions, but not with tests that tapped frontal lobe functions. This finding is in contradiction to the view held by other authors [17], that lesions to frontal structures produce an 'action disorganization syndrome', although it is consistent with the observation of spared performance on naturalistic actions in nine patients with frontal lobe lesions [18].

In addition to replicating the observation that LBD as well as RBD patients have difficulties in performing naturalistic actions, Hartmann *et al.*'s study provides the additional insight that the patients' difficulties have different causes depending on the side of the brain damage. Thus, the resource limitation account might be an adequate explanation for RBD patients, but not LBD

patients for whom the crucial factor seems to be the cognitive demands of the task.

Challenging research on apraxia

For years, patients have been clinically tested for possible apraxic deficits using simple tasks such as lighting a candle or posting a letter. Hartmann *et al.*'s study has the additional merit of including in the clinical assessment of apraxia the use of technical devices, as they are increasingly part of our everyday lives. Verifying how patients cope with technical devices after brain damage therefore has obvious ecological validity. The clinical evaluation should not be seen in opposition to a cognitive approach that uses controlled experiments in which patients are asked to engage in more artificial tasks. Ideally, the two procedures should be combined. Neuropsychology remains an essential research tool: having an accurate clinical description of patients' praxic deficits is the fundamental, starting point for making reliable inferences about the normal organization of higher-motor skills.

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Book Reviews

More to the mind than meets the eye

The Oxford Companion to the Mind, 2nd edition, edited by Richard L. Gregory, OUP, 2004. £40.00/$75.00 (xx+1004 pp.)
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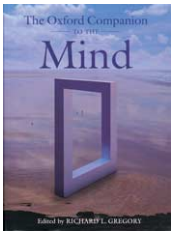

This is the second edition of the Richard Gregory's much-loved 'Companion', which first appeared nearly 20 years ago. The new edition is about 20 per cent longer than the old, whether because of the accumulation of new knowledge, or of new fashion, it is for the reader to judge. Certainly, there are many new entries, some of which are helpfully listed on the cover: autism, conjuring, false memories, phantom limbs, qualia, tickling – these give an idea of the delights within. A new feature is the inclusion of several lengthy multi-authored tutorials, one on consciousness and another on brain imaging, for example. The Preface explains that psychoanalysis has been downgraded, and that the extended tutorial on the nervous system has been abandoned, because of easily accessible tutorials elsewhere.

The new edition has many of the strengths of the old. Opened at a random page it will generally provide instruction and amusement. Where else will one find in a single volume a lengthy (and good) article on Lord Adrian and also one on St Thomas Aquinas? The book will be an excellent tool for students in psychology and philosophy, and a serious source of information for the non-specialist, at whom it is principally aimed. It is reasonably priced and nicely produced in type that could be read by this presbyope (not included, by the way, and neither is 'myopia').

Looking at the book from the perspective of a narrow specialist in visual perception, I naturally found many

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