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DIALOGUE

The central executive: A concept and some misconceptions

ALAN BADDELEY

Department of Experimental Psychology, University of Bristol, Bristol, U.K.

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Abstract

Parkin's criticisms of the central executive are based on a series of misconceptions. The central executive is not an organ that might or might not exist, but a scientific concept. Part of its function is to separate the analysis of executive processes from the question of their anatomical location. Like other components of working memory, it is fractionable into subsystems. How the subsystems interrelate and how they map onto the anatomical substrate are empirical questions under active current investigation. (*JINS*, 1998, *4*, 523–526.)

Keywords: Working memory, Central executive, Frontal lobe syndrome, Dysexecutive syndrome

INTRODUCTION

As Parkin points out, the concept of a central executive was proposed by Baddeley and Hitch (1974) as part of their expansion of the earlier concept of a unitary short-term memory into a multicomponent working memory. It remained an undeveloped component of the model until Baddeley (1986) suggested that it might be useful to conceptualize the executive in terms of the SAS model developed by Norman and Shallice (1986). Despite the complexity of the problem of executive control, the model has proved fruitful and is continuing to show considerable development. It is therefore unfortunate that Parkin has chosen to create and criticize an amalgam of the working memory and SAS models as they were 10 years ago. It is, however, clear from many discussions that such misinterpretations are by no means uncommon, and I therefore welcome the opportunity of attempting to correct them. My comments will be confined to discussion of the concept of working memory, but I suspect that Shallice would share my concern about several of the misconceptions implicit in Parkin's critique and would like to refer the reader to a recent paper (Shallice & Burgess, 1996) in which, far from proposing a unitary module of the type criticized, they differentiate no fewer than eight executive sub-processes.

Parkin's criticism rests on his assumption that the central executive reflects a modular system that is coterminous with the frontal lobes. His criticism focuses on the assumption of a unitary system whose validity depends upon the capacity to map it onto a single anatomical location. I agree that these are implausible assumptions, and have in fact spent a good deal of time over the last decade attacking them (Baddeley, 1996a; Baddeley & Wilson, 1988). I suggest that a number of important misconceptions underlie Parkin's criticisms, misconceptions that are likely to present problems for any approach to executive function. For that reason I believe they are worth spelling out in greater detail. They concern

1. the basic scientific philosophy underlying Parkin's approach;
2. the tendency to assume that a coherent functional concept must have a unitary anatomical location;
3. the assumption that, because a system functions as a whole, it is therefore modular and nonfractionable; and finally,
4. the assumption that a system with homunculus-like properties is likely to be scientifically sterile.

Reprint requests to: Alan Baddeley, FRS, University of Bristol, Department of Experimental Psychology, 8 Woodland Road, Bristol BS8 1TN, U.K. E-mail: Alan.Baddeley@bristol.ac.uk

I conclude by briefly outlining some evidence for the value of the working memory approach to executive control in terms of what it has so far achieved.

SOME PRETHEORETICAL ASSUMPTIONS

As a scientist, I assume that my task is to develop concepts and theories that give an economical account of what we already know, in ways that facilitate the acquisition of further knowledge. Like any other concept, I assume that the central executive should be judged by its usefulness in accounting for what we know and facilitating further research. I do *not* regard it as a hypothesis that requires a yes/no answer if it is to be useful, nor do I regard it as an internal organ whose existence depends upon an exact mapping of function to precise anatomical location. Hence, to deny the existence of the central executive is to commit a category error; the concept of the central executive certainly does exist. The important scientific issue is whether it is a *useful* concept. Note that to be useful, a concept does not have to be in any absolute sense "true" or "correct." The concept in physics of the atom as an irreducible unit of matter has been superseded by fractionation into progressively more detailed components, but that does not invalidate the earlier usefulness of the concept in forwarding the development of physics.

FUNCTION AND ANATOMY

The study of executive processes has in the past been bedeviled by the tendency to conflate the study of executive deficits with their hypothetical location within the frontal lobes. Baddeley and Wilson (1988) argued against this approach on the grounds that

A. executive processes need not be unitary;

B. the frontal lobes represent a large and multi-faceted area of the brain, which is unlikely to be unitary in function;

C. executive processes are likely to involve links between different parts of the brain and hence are unlikely to be exclusively associated with a frontal location;

D. consequently patients may conceivably have executive deficits without clear evidence of frontal damage; and

E. patients with frontal lesions will not always show executive deficits.

The concept of a "dysexecutive syndrome" was proposed explicitly to allow the discussion of function to be separated from the question of the anatomical location of such functions. It is therefore somewhat ironic to find Parkin using the absence of a simple mapping of executive function onto anatomy as an argument against the concept of a central executive.

THE CENTRAL EXECUTIVE AS A UNITARY SYSTEM

As Parkin observes, the central executive was represented in the original model as a large unfilled ovoid. The reason that it was unfilled was that we knew virtually nothing about its functions. My own theoretical style is to allow the model to be constrained by the data, not to postulate complex hypothetical mechanisms that in the absence of constraining evidence will almost certainly be wrong. Given the way in which the simpler phonological and visuospatial slave systems have fractionated into subcomponents as we understood them further (Baddeley, 1996b), it seems inconceivable that the central executive will not also fractionate into subsystems. Over the last decade we have therefore been gradually attempting to find ways of breaking the system up into components, beginning with the study of dual task performance (Baddeley et al., 1986) and subsequently postulating other executive processes involving the focusing of attention, attention switching together with a system concerned with the control of long-term memory (Baddeley, 1996a). Such an approach does not of course yield a simple empirically testable yes/no hypothesis, but rather represents a way of progressively investigating an important but extremely complex set of processes. Having established a *prima facie* case for a particular function, it then makes sense to attempt to localize it anatomically, as was done successfully in the case of the capacity for dual task performance (D'Esposito et al., 1995). Such an approach leaves open the question of whether the resulting executive processes will prove to operate in a hierarchical way with one particular process being of overwhelming importance, or whether the central executive system may be better considered as an alliance amongst processes of approximate equal weight.

This might be a good point to correct the impression given by Parkin that the BADS (Wilson et al., 1996) was developed on the assumption that it was measuring a single unitary executive. The test was influenced by the concept of a dysexecutive syndrome, in proposing to separate the executive functions from the question of their anatomical localization, but was not specifically associated with the working memory model; it certainly did not assume a single unitary executive system (B.A. Wilson, personal communication, 1997). The whole purpose of including a range of different tests, originating from different theoretical traditions, was to maximize the likelihood of detecting executive deficits of any kind. In short, the aims of the BADS test were clinical and pragmatic, and its theoretical background eclectic.

WHEN A HOMUNCULUS IS HELPFUL

As Parkin points out, the central executive in the original working memory model is little more than a homunculus, a little man who takes all the decisions that are beyond the capacity of the slave systems. Viewed as a testable hypothesis, a homunculus is clearly a thoroughly bad thing. However, as a way of partitioning a complex area, even a

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homunculus can be useful. In the first instance, the homunculus allowed us to concentrate on the simpler and more tractable slave systems, while still acknowledging that they are capable of being influenced by more complex strategic factors. By labeling such additional factors as the central executive, we implied a commitment to investigate them, a commitment on which we are now busily engaged (Baddeley, 1996a; Baddeley et al., 1997).

But how should one deal with a homunculus? The first task is to specify the jobs that it performs. In the case of the central executive we have already suggested the need for several executive functions, including dual task performance, attentional focusing, attention switching, and interfacing with LTM. Such executive processes can then be tackled one at a time, with more detailed analysis being followed by a stage in which the separability of the specified executive subprocesses is tested and their interrelationship explored. One hopes eventually to reach a point at which each of the homunculus' tasks has understood, making the homunculus redundant (see Baddeley, 1996a; Baddeley & Della Sala, 1996, for further discussion).

HOW USEFUL IS THE CONCEPT OF A CENTRAL EXECUTIVE?

The concept of a central executive represents just one of a number of possible approaches to the analysis of executive processes. Such processes are enormously important, but are probably the most complex aspects of human cognition and, as such, are unlikely to be fully understood in the near future. I would however suggest that the central executive concept has already proved useful in the following ways. First, in separating out the complex aspects of attentional control from the slave systems, it has facilitated the understanding of both phonological and visuospatial short-term memory. Secondly, the concept of a dysexecutive syndrome has proved useful in disentangling the functional analysis of the executive processes from the important but separate question of their anatomical location.

A good example of this is the application of the working memory model to Alzheimer's disease (AD). Analysis of the cognitive deficit in AD patients suggested a central executive impairment (Morris & Baddeley, 1988; Spinnler et al., 1988). Tasks were developed to test this hypothesis, leading to evidence for a differential disruption (Baddeley et al., 1991), while subsequent application of the tasks to patients with frontal lobe damage produced evidence both for a fractionation of executive processes and for the dependence of dual-task control on the frontal lobes (Baddeley & Della Sala, 1996; Baddeley et al., 1997). Further support for the control of dual task performance by the frontal lobes was independently obtained by D'Esposito et al. (1995) in a PET-based functional imagery study.

Finally, at a conceptual level, the increasing use of the term "dysexecutive syndrome" by investigators who are not specifically concerned with the working memory model suggests that the concept is serving a useful function. The use of a functional term rather than the anatomically based term "frontal syndrome" does not of course mean that data concerning the anatomical localization of executive processes are unimportant. But it does imply that it is pragmatically useful to be able to separate the analysis of function from the question of anatomical localization.

Having identified potential executive processes and having tested them across a range of different tasks and material, anatomical localization can then be used as a possible source of further evidence for a distinct and separable process. It is important to bear in mind, however, that specifying a function and investigating its characteristics is not dependent on that function having a unitary anatomical localization.

CONCLUSION

The central executive certainly exists, but as a concept—not as a modular organ coterminous with the frontal lobes. As in the case of other components of working memory, it is proving to fractionate into subcomponents and, in doing so, provides a useful basis for studying the complexities of executive control and identifying subprocesses, which may then be mapped on to their anatomical substrate.

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