DISCUSSION

BEYOND TASK DISSOCIATION LOGIC: A RICHER CONCEPTION OF COGNITIVE NEUROPSYCHOLOGY

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Analyzing the rationale for relating cognitive deficits to issues of normal cognition is a worthwhile enterprise. However, the conclusions reached can be only as valid as the assumptions upon which the analyses are based. In this note I suggest that most recent analyses rest upon unduly restrictive assumptions about the nature of the evidence in cognitive neuropsychological research, and the processes of interpreting that evidence. Adopting a richer conception of cognitive neuropsychology leads to different conclusions about the nature and interpretation of evidence in the field.

TASK DISSOCIATION LOGIC

Both advocates and opponents of cognitive neuropsychology almost always assume that cognitive deficits can be brought to bear on issues of normal cognition only through what I will call *task dissociation logic*. On this view cognitive neuropsychology is a method for drawing inferences of the form, "Task A and task B involve different processing mechanisms". The method is applied by testing patients on two or more tasks, and interpreting the observed dissociations and associations of deficits according to the following principles:

Single dissociations. A finding of impaired performance on one task with normal (or at least reliably better) performance on another suggests that the tasks differ in one or more of their underlying processing mechanisms. However, this pattern of results – a single dissociation – does not constitute compelling evidence for different processing mechanisms; an alternative interpretation is that both tasks require the same processing mechanisms, but one task demands more from these mechanisms than the other, and consequently shows greater impairment when the mechanisms are damaged.

Double dissociations. Because single dissociations are subject to this potential *resource artifact* interpretation (Shallice, 1988), stronger evidence is needed to warrant a firm conclusion that two tasks differ in underlying processing mechanisms. In particular, what is required is a double dissociation, in which one or more patients show poor performance on task A with good performance on task B, while one or more other patients show good performance on task A with poor performance on task B. A double dissociation rules out resource artifact interpretations. To interpret the A-good-B-poor dissociation in terms of resource

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artifacts one would have to assume that task B places heavier demands than task A on the required processing mechanisms; but to interpret the complementary A-poor-B-good dissociation one would have to make the contradictory assumption that task A demands more than task B from the mechanisms.

Associations. A pattern of results in which performance is impaired on both task A and task B – an *association* – might seem to suggest that the tasks share one or more processing mechanisms, given that damage to a shared mechanism would be expected to produce impairment on both tasks. However, the association could also have resulted from two separate deficits, one affecting task A and the other affecting task B. As a consequence, associations are uninformative about underlying processing mechanisms.

Task dissociation logic has been widely discussed in the cognitive neuropsychology literature. Some discussions have been aimed at formulating the logic more precisely, addressing such matters as what specific forms of double dissociation are required to warrant conclusions of separate processing mechanisms (e.g., Jones, 1983; Shallice, 1988). Other commentators have criticized the logic or some of its applications (e.g., Plaut, 1995; Robertson et al., 1993; Van Orden et al., 2001), arguing for example that double dissociations do not necessarily imply a difference in processing mechanisms between tasks (e.g., Chater and Ganis, 1991; Ganis and Chater, 1991; Plaut, 1995; Van Orden et al., 2001; but see Bullinaria and Chater, 1995).

Virtually all of the discussions have taken as given that task dissociation logic represents the sole method for relating cognitive deficits to theories of normal cognition. Accordingly, proponents of the logic have offered their analyses as prescriptions of how to do cognitive neuropsychological research, and opponents have presented their arguments as indictments of cognitive neuropsychology in general.

My aim here is not to evaluate specific formulations of, or objections to, task dissociation logic. Rather, my goal is to question the assumption that cognitive neuropsychology can proceed only through application of this logic, and to offer a different view of inference-making in cognitive neuropsychological research.

Mistaken Presuppositions

The assumption that task dissociation logic represents the only way of doing cognitive neuropsychology rests upon two mistaken (and usually unstated) presuppositions. The first is that the data obtainable from studies of cognitive deficits are necessarily crude (e.g., Shallice, 1988), and in particular are limited to gross level-of-performance measures (e.g., percent correct) on a small number of tasks. The second presupposition is that interpretation of evidence is a fixed mechanical process in which the logical consequences of the data are assessed in isolation from any other empirical or theoretical considerations.

Given these presuppositions, it appears self-evident that cognitive neuropsychology is limited to conclusions of the form, “Task A and task B

differ in at least one processing component"; that the conclusions can only be drawn by applying the principles of task dissociation logic; and that if the task dissociation principles are flawed, that cognitive deficits cannot provide a sound basis for inferences about normal cognition. However, the presuppositions have no basis in canons of scientific method, practice in other areas of cognitive science, or intrinsic characteristics of cognitive deficits.

Cognitive Neuropsychology More Broadly Conceived

Fortunately, a broader conception of cognitive neuropsychology is evident in much of the recent work in the field. A growing body of research demonstrates that cognitive neuropsychological data are not limited to dissociations between tasks in overall level of performance, and that the interpretation of data is not restricted to the application of task dissociation logic. The impaired performance of individuals with cognitive deficits is often richly patterned, and careful analysis of the patterning can provide a basis for specific, fine-grained inferences about cognitive representations and processes. For example, several recent studies of individual dysgraphic patients converge on conclusions about the orthographic representations underlying the ability to spell words in writing, typing, spelling aloud, and so forth. These studies provide evidence that orthographic representations are not simple linear sequences of letter tokens (e.g., C-R-O-S-S for the word *cross*), but rather are complex multidimensional structures in which (a) orthographic syllable structure is represented (Caramazza and Miceli, 1990); (b) information about the orthographic consonant/vowel status of each letter is represented independently of the letter's identity (Caramazza and Miceli, 1990; Cubelli, 1991; McCloskey et al., 1994); and (c) information about letter doubling is specified separately from the identity of the doubled letter (Caramazza and Miceli, 1990; McCloskey et al., 1994; Tainturier and Caramazza, 1996; Venneri and Cubelli, 1993). The evidence concerning representation of letter doubling is illustrative.

Patient HE (McCloskey et al., 1994) presented with several systematic phenomena in spelling words with double letters, including *doubling shift* errors, in which he doubled the wrong letter:

Stimulus	*Response*
shell	sheel
needle	neddle
across	accros
parrot	parott

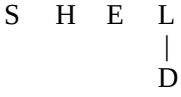
The doubling shift errors, and other aspects of HE's performance, were inconsistent with the assumption that double letters are specified in orthographic representations simply by two tokens of the to-be-doubled letter (e.g., S-H-E-L-L). McCloskey et al. (1994) argued that the results could be interpreted only by assuming that double letters are represented by a single letter token associated with a separate specification of doubling.

Patient LB (Caramazza and Miceli, 1990) also exhibited a systematic pattern of errors in spelling words with double letters. Among the more striking aspects of this pattern were errors such as the following:

Stimulus	*Response*
pezzo	zeppo
cellula	leccula
blocco	bcollo

These *doubling exchange* errors are extremely difficult to reconcile with representations in which double letters are specified by two tokens of the to-be-doubled letter (e.g., P-E-Z-Z-O). Results from other patients also suggest that double-letter representations are in some way special (e.g., Tainturier and Caramazza, 1996; Venneri and Cubelli, 1993).

Caramazza and Miceli (1990) proposed that in normal orthographic representations, double letters are represented by a single letter token associated with a doubling marker, as illustrated below for the word *shell*:



This doubling mark hypothesis provides a basis for interpreting the various observed patterns of impairment. For instance, HE's doubling shift errors (e.g., *shell* → *sheel*) may be explained by assuming that his orthographic representations were sometimes disrupted in such a way that the doubling mark became associated with the wrong letter token:

LB's double exchanges (e.g., *pezzo* → *zeppo*) can also be interpreted, by assuming that the single token of the to-be-doubled letter was exchanged with the token for another letter in the word:

Taken together, the results from the various studies make a compelling case for the conclusion that double-letter representations involve a single letter token associated with a separate specification of doubling. This conclusion forms one pillar of the broader argument that orthographic representations are complex multi-dimensional structures, rather than simple linear sequences of letter tokens.

I have developed this example to illustrate several points. First, cognitive neuropsychological evidence need not be limited to dissociations between tasks

in gross performance-level measures, and the inferences drawn from the evidence need not be limited to coarse-grained conclusions of the form, «Task A and task B involve different processing mechanisms.» The impaired performance of individuals with cognitive deficits is often richly structured, and careful analysis of the structure can provide a basis for fine-grained conclusions about cognitive processes and the representations upon which they operate.

Second, interpretation of cognitive neuropsychological evidence need not – and indeed should not – involve the mechanical application of task-dissociation logic. Many forms of potentially-relevant data (e.g., the error patterns exhibited by HE and LB) do not fit neatly into any of the evidential categories defined by this logic (i.e., single dissociation, double dissociation, association), and the reasoning that links data to conclusions does not involve the mindless application of task dissociation principles.

An important implication of these points is that arguments against task dissociation logic (e.g., arguments that separate processing mechanisms cannot be inferred from double dissociations) do not constitute blanket indictments of cognitive neuropsychological research. These arguments – whether or not they raise valid objections to task dissociation logic – are simply irrelevant to research not based on this logic.

Even when results are straightforwardly describable as dissociations or associations, the process of interpretation is often not restricted to application of task dissociation logic, and the arguments against this logic often do not apply. For example, Rapp et al. (1997) reported a single dissociation in which patient PW, on some trials of a picture naming task, made semantic errors in naming the picture orally, yet wrote the name correctly. Thus, shown a picture of an owl and asked to say and then write the name several times in succession, PW responded as follows:

Spoken: «turtle»
Written: owl
Spoken: «turtle»
Written: owl
Spoken: «turtle»
Written: owl

Arguing from other aspects of PW's performance that the oral-naming errors reflected an impairment in accessing phonological word representations, Rapp et al. (1997) interpreted the dissociation between written and spoken naming as evidence against the *phonological mediation* hypothesis, which assumes that the orthographic representations mediating written word production can be accessed only via phonological representations (i.e., semantics → phonology → orthography). Rapp et al. instead endorsed an *orthographic autonomy* hypothesis, according to which orthographic representations may be accessed directly from semantic representations, without phonological mediation.

According to task dissociation logic, we should consider Rapp et al.'s argument questionable, on grounds that their single dissociation might have resulted not from a difference in processing mechanisms between spoken and written naming,

but rather from a resource artifact (i.e., spoken naming demanding more than written naming from the same processing mechanisms). Further, we should believe that the Rapp et al. conclusion would be buttressed by results providing the other half of the double dissociation (i.e., good oral but poor written naming). However, this application of task dissociation logic would be seriously misguided. To attribute the Rapp et al. (1997) findings to a resource artifact one would have to assume that retrieval of phonological word representations is a more demanding process in the spoken naming task than in written naming task. However, such an assumption would be not only highly unmotivated but also highly implausible, especially given that the principal alternative to Rapp et al.'s interpretation – the phonological mediation hypothesis – would presumably hold that the phonological retrieval process is identical in spoken and written naming.

Furthermore, results providing the other half of the double dissociation would do very little to strengthen the Rapp et al. (1997) argument. Suppose we had results from one or more patients showing impaired written naming in the presence of intact spoken naming, and more specifically impaired access to orthographic representations in the presence of normal access to phonological representations. Although these results would certainly be consistent with Rapp et al.'s orthographic autonomy hypothesis, they would be equally consistent with the phonological mediation hypothesis, and indeed with virtually any hypothesis positing that access to orthographic representations is implicated in written naming but not in spoken naming. Hence, the findings would add little to the support for the orthographic autonomy hypothesis, and would be far less useful than additional evidence suggesting specifically that access to phonological representations is not required for access to orthographic representations (e.g., results from oral and written sentence completion similar to those reported by Rapp et al. for oral and written picture naming).

Note also that for the Rapp et al. (1997) study, like the double-letter studies, the arguments against task dissociation logic are simply beside the point; hence, we see once again that these arguments by no means call all of cognitive neuropsychology into question.

Both of the examples I have developed drive home the point that contrary to the assumptions underlying task dissociation logic – and the arguments offered against this logic – the weight of various categories of cognitive neuropsychological evidence cannot be assessed in a vacuum. Like other forms of evidence in cognitive science (or indeed in any science) cognitive neuropsychological data can and should be evaluated in the light of such considerations as the particular theoretical issues under investigation, the tenable alternative positions on these issues, and the specific form of the evidence. Once this point is recognized it becomes clear that circumscribing *a priori* the forms of data to be considered, or the reasoning to be used in linking data with theory, is neither possible nor desirable.

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