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Distributed versus Localist Representations: Evidence from a Study of Item Consistency in a Case of Classical Anomia

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Models of word production and comprehension can be split into two broad classes: localist and distributed. In localist architectures each word within the lexicon is represented by a single unit. The distributed approach, on the other hand, encodes each lexical item as a pattern of activation across a set of shared units. If we assume that the localist representations are more than a convenient shorthand for distributed representations at the neuroanatomical level, it should be possible to find patients who, after brain injury, have lost specific words from their premorbid vocabulary.

Following a closed head injury, JS had severe word-finding difficulties with no measurable semantic impairment nor did he make phonological errors in naming. Cueing with an initial phoneme proved relatively ineffective. JS showed a high degree of item consistency across three administrations of two tests of naming to confrontation. This consistency could not be predicted from a linear combination of psycholinguistic variables but the distribution fitted a stochastic model in which it is assumed that a proportion of items have become consistently unavailable.

Further evidence is presented which suggests that these items are not, in fact, lost but rather have a very low probability of retrieval. Given phonemic cueing of sufficient length, or delayed repetition priming from a written word, the consistently unnamed items were produced by JS. Additional data is reported which seems to support a distributed model of speech production. JS's naming accuracy for one set of pictures was found to predict his performance on a second set of items only when the names of the pictures were both semantically and phonologically related (e.g.,

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cat–rat). There was no association for pairs of pictures if they were only semantically (e.g., cat–dog) or phonologically related (e.g., cat–cap).

It is argued that JS's data are best described in terms of a graded, non-linear, distributed model of speech production.

INTRODUCTION

Models of word recognition and production can be split into two broad classes. One collection of models contains representations in a localist form, i.e., they contain single entities or nodes each of which corresponds directly to one, and only one, representation. Distributed models, on the other hand, do not use this one-to-one correspondence, but rather code each representation as a pattern of activation across a number of elements; each element can be utilized as a component of many different representations. The logogen model of Morton (1985) and the interactive activation model of Dell and colleagues (Dell, 1986; Dell & O'Seaghdha, 1992) both contain a single layer of units in which each unit corresponds to a single lexical item. Similarly, two-stage models of speech production (Butterworth, 1989; Levelt, 1989, 1992) contain two sequential layers of localist representations. Distributed models (e.g. Plaut & Shallice, 1993; the ''triangle'' model: Seidenberg & McClelland, 1989; Plaut, Seidenberg, McClelland, & Patterson, 1996), on the other hand, treat speech production as a process in which both semantic and phonological representations are coded across a number of nodes. Although they employ a set of hidden units between the semantic and phonological layers, this cannot be thought of as a lexicon in the traditional sense because, for different words, considerably overlapping sets of hidden units participate in activating phonology from semantics.

Localist and distributed representations predict different patterns of impairment in aphasic production. If representations are stored (in the brain) in a localist form[1] then it should be possible to identify patients whose anomia is best conceptualized as resulting from the loss of specific lexical entries. If a selection of words has been removed from patients' premorbid vocabulary, it should be impossible for these items to be retrieved under any circumstances. Such patients should *never* produce the picture names even if the tests are accompanied by procedures designed to facilitate production such as phonemic cueing or priming.

Distributed models predict that particular single items cannot be entirely lost while leaving the remaining vocabulary undamaged. These models are, in fact, resistant to small amounts of damage while greater degrees of impairment lead to a proportional increase in dysfunction across the entire vocabulary, a property known as *graceful degradation* (McClelland, Rumelhart &

[1] Not all researchers assume that localist units within a computational model translate directly into localist, neuroanatomically based representations (see ''Discussion'') but some authors do (see Howard, 1995; Page, submitted).