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The modularity thesis: its implications for interpretations of priming effects

Christopher W. Davis
Universidad Complutense de Madrid

Abstract

The aim of this paper was to show that Fodor's modularity thesis provides a framework for interpreting data thought to be relevant to the structure of the language processor. In setting out a background to this, the basic research enterprise of isolating processor properties was considered, with an emphasis on the logic underlying the use of a particular experimental technique (repetition priming) as a way of determining processing architecture within the language module. This enterprise was considered with respect to Fodor's account of mental architecture; the suggestion being made is that in its traditional form, the priming technique will give ambiguous results. In order to overcome this, a modification to the priming technique was investigated.

Resumen

El objetivo de este artículo es mostrar que la tesis de la modularidad de Fodor proporciona un marco de trabajo desde el que se puede interpretar datos relevantes sobre la estructura del procesador del lenguaje. Para ello, se propone aislar propiedades de dicho procesador, utilizando la lógica subyacente a la técnica experimental del «priming de repetición» como medio para determinar la arquitectura de procesamiento dentro del módulo del lenguaje. Esta linea de investigacion se examina considerando la propuesta de Fodor sobre la arquitectura mental. Finalmente, se sugiere que la técnica de «priming» en la forma que se ha utilizado tradicionalmente proporciona resultados ambiguos, y se propone una modificación de la misma.

The primary interest of this paper concerns the possible implications of Fodor's modularity thesis for experimental inquiry in psycholinguistics. Specifically, the assumptions implicit in the use of a particular experimental task thought to index lexical structure will be examined in order to show how theories of mental architecture and the interpretation of data interact. In order to see how these two are linked it is necessary to provide some background into research concerning visual word recognition.

The priming paradigm has become one of the most extensively used techniques in the study of visual word recognition. The term *priming* has had broad application in the word recognition literature. It seems to have been used to describe virtually any situation where a facilitation in performance for one stimulus occurs, given an encounter with another. The idea, simply put, is that an initial stimulus input, the *prime*, benefits the processing of a subsequent input, the *target*. Priming effects have been shown to occur over a range of prime-target relationships: in *repetition* priming, the prime and target stimuli are the same (Scarborough, Cortese and Scarborough, 1977); in *semantic* and *associative* priming, there is either a meaning-based or an experiential link between the prime and target (Meyer and Schvaneveldt, 1971); and in *form* priming, the prime and target share properties of form (Hillinger, 1980).

Effects of this kind have been used to make inferences about the properties of the information processing systems underlying word recognition performance. The particular interest of this paper centers on repetition priming and the variables influencing its occurrence and magnitude in experiments which typically use the lexical decision task. In these experiments, the dominant dependent variable is response latency, a measure which is assumed to reflect the duration of processes involved in word recognition.

When items are repeated in a lexical decision experiment, with first encounters acting as primes for second encounter targets, response latencies for target words in general decrease markedly. This holds true even when a considerable time (say, 20 minutes or more) elapses between successive presentations (Forbach, Stanners, and Hochhaus, 1974; Kirsner and Smith, 1974; Scarborough, Cortese and Scarborough, 1977).

This finding, henceforth referred to as the *repetition priming effect*, has been interpreted by many investigators in terms of a reduction in the processing time required for the *recognition* of the target word. The mechanism proposed to account for this reduction varies with the theoretical position adopted to explain word recognition, in general. For example, Morton (1979) interprets the finding within his system of logogens, the evidence-gathering detectors whose activation is the basis of word recognition in this theoretical framework. Where the same logogen can be activated by both prime and target, the raised activation level which is a product of the prime presentation is said to persist, to permit a reduction in the evidence, and hence time, required for the target to raise activation above threshold.

Regardless of any particular theoretical stance, the assumption that repetition priming reflects some change in the processes underlying word recognition has important consequences. In particular, it leads the investigator to interpret variables which modulate the size of the repetition priming effect as yielding information about lexical organization. In the end, the interest is not in repetition priming, per se, but in its use as a means to probe the lexical component of the language processor.

To illustrate the way the arguments about lexical structure are constructed on the basis of facts about repetition priming, consider Morton's (1979, 1980) use of his finding that the effect is eliminated when primes and targets are presented in different modalities. Because Morton treats repetition priming as a purely lexical effect, he is obliged to postulate that each word has a separate representation (logogen) for each input modality. A modality dissociation in the repetition priming effect translates to a modality dissociation in lexical architecture: auditory presentation of a word leads to residual activation in its phonological logogen, but not in its orthographic logogen.

Monsell (1987) has adopted a similar strategy for carving up the language processor. Treating repetition priming as the product of temporary modifications to the processes of lexical access, he argues from the results of a range of experiments that the orthographic lexicon should itself be divided; writing a word, it seems, does not necessarily activate the orthographic lexicon used in reading. The priming technique has also been used as a research tool to study the basis of bilingual lexical representation, with the failure of priming from one language to another being regarded as evidence for separate, non-connected lexicons. The unstated idea in all these studies has been that this task gives a *theory free* look at mental structure. In order to understand why this might not be the case, we need to consider why the modularity thesis cautions against making such inferences.

Fodor's modularity thesis is a proposal about mental organization and the division of mental labor between processing domains. The primary claim is that there *is* a mental architecture in which the information exchange between processors is limited. This restriction thereby sets a boundary on those confirmation relations needed to determine perceptual belief. Fodor (1983) has proposed that the fixation of any perceptual belief involves the operation of three functionally distinct systems. At the interface between the organism and the environment, *transducers* convert sensory stimulation into some form of low-level neural code. Computations are then performed on these transducer outputs by *input systems*, which yield hypotheses about the nature of the distal object underlying the proximal stimulus configurations at the transducer. Finally, *central systems* arrive at a belief about the external object by correcting the outputs of an input system in the light of background knowledge and of the output of other input systems.

For Fodor, the language faculty is a strong candidate for an input system. In common with all input systems, a language processor is *modular* in possessing a number of properties. For example, it is domain specific (its processes operate only on inputs of a specified kind, and its outputs are similarly limited); its operation is mandatory (given an appropriate input, its processes automatically run their course); and its working products are unlikely to be accessible to central systems, and hence to consciousness (see Fodor, 1983, pp. 47-101).

The idea of a modular language processor is reflected in theories of lexical access which regard the lexicon as a data-base in the service of sentence processing devices. What follows naturally from this is that those vocabulary features which are crucially involved in language processing are recorded in the database (e.g., spelling, pronunciation, syntactic class, and so on), while other incidental facts are not. To put it

succinctly, the lexicon is placed within an input module (see Fodor, 1983; Forster, 1979; Seidenberg, 1985).

Now ifthe modular view is taken seriously, a problem now arises in the interpretation of priming effects. For these effects could be generated in a number of ways and at markedly different locations in the perceptual-cognitive apparatus. At lower levels storage may be simply be a change in state in the operating characteristics of a transducer. At the highest level, the fact that a priming event has occurred may be stored as a record of a perceptual belief, fully elaborated. This seems to be an inevitable problem in the study of mental processes, for «overt, observable behavior is an interaction effect par excellence» (Fodor, 1983, p. 1). That is, a researcher's dilemma is that observed behavior is the joint product of contributing sub-systems which may differ from each other in important ways. The individuation of the separate contributions of different sub-systems is likely to be difficult. In particular, data which are presumed to yield information about the structure of an input module (e.g., data about repetition priming effects with word materials) are likely to be contaminated by the influence of systems outside this module (e.g., central memory effects).

The task of eliminating competing explanations of putatively lexical phenomena is not a newly arising one. Coltheart (1978) makes a cautionary point with respect to the suitability of methods for examining lexical processing:

> If we wish to discover how lexical access is achieved, it seems advisable to use experimental tasks which cannot be performed in the absence of lexical access, but require little else. (p. 170)

The problem is, if anything, exacerbated by the fact that most available language tasks and performance measures involve the operations of the highest levels of the cognitive apparatus (Forster, 1985, p. 9). If the properties of a *particular* processing system are to be investigated, experimental ingenuity is called for to ensure that variations in the performance measure reflect only processes within that system, with the contribution from other processors minimized.

In sum, what cannot be disregarded is the possibility that although a task includes language module processes, it may also include something more. Since behavior in a language task is determined jointly by the products of the language module and higher inferential systems, «lexical decision times will reflect lexical access times only to the extent that irrelevant influences have been eliminated» (Forster, 1985, p.10). Forster's observation is not of course particular to lexical decision latencies, or even to latencies more generally, though it has real force in the case of repetition priming. If an initial encounter with a word is to have an effect at a later stage, it must be stored in memory. The critical question is *which* memory or system: a specialized lexical memory, or central system - a general memory for episodes? For the interpretation of patterns of repetition priming, it is perhaps not so much a question of controlling for «irrelevant influences», but of deciding upon the system to which the effect is relevant.

Thus, from the modularity perspective, the problem becomes to limit central processing involvement, while still allowing the input system (the lexicon) to complete its processing. How might this be done? The modularity view itself offers a clue, for Fodor's (1983) view of the architectural arrangements governing exchanges of informa-

tion between input systems and mechanism of cognition permits a plausible account of «cognitive masking» of the central processing system.

The relevant properties, here, concern the way input systems interface with central ones. As outlined earlier, input systems are modular and rapid, while the fixation of perceptual belief handled by central systems is informationally promiscuous and relatively slow. Moreover, belief fixation is sensitive to the utilities of the organism, e.g., the attentional demands present in any given situation. The interplay of these properties, as it pertains to a possible masking situation, has been neatly summarized by Holender (1986):

> What is fascinating in [Fodor's] theoretical formulation is precisely that a good (supraliminal) sensory input (1) can undergo a fair amount of processing into a modular input system, including lexical access, without necessitating any intervention from the central processor and (2) that the central processor can be ignorant of the fact that such processing has occurred (p. 60).

This approach then, suggests that a prime stimulus could affect the state of a representation within the lexical input module, but its effect upon subsequent perceptual belief might be negligible because of the action of an appropriately timed mask. It should also be stressed that in adopting an approach more in terms of the allocation of attentional resources, the nature of unconscious capacities are not at issue.

As it turns out, experiments have shown that this may be achievable in practice (e.g., Forster and Davis, 1984). In these experiments, the display characteristics of masks and prime are set so that the subject has no *explicit* memories of the prime event, even though a robust repetition priming effect is observed. Thus masking the prime apparently provides a straightforward way to restrict the possibility of truly high level memories.

In order to be confident that the technique of *masked* priming overcomes the interpretation problem, it is necessary to show that it is sensitive solely to aspects of the input system. Yet if these aspects could be specified in advance, research would be made unnecessary; in practice we are limited to an indirect approach, showing that masked priming is *not* influenced by either pre- or post-input system properties.

One possibility is that masking the priming stimulus has created unusual conditions in early perceptual or even «neural» territory, that is, in the process of sensory transduction. For this to occur, the neural signals of prime and target would need to interact; or if it were sited at the level of preliminary perceptual analysis, the processes identifying features of the stimulus shape might be conflated across successive inputs. But this does not seem to be the case, for an experiment (Davis and Forster, 1991) which used prime-target pairs specifically designed to be either legible or illegible when fused together show no differential effects. Further, other experiments (Davis, 1990) have shown that the amount of priming drops off very sharply as the prime differs from the target. This suggests that stimulus registration of the prime is very good, and once again implies that the prime and target are not visually degraded.

At the other extreme, higher level decision processes (central systems) have also to be ruled out, as experiments (Davis, 1990) suggest that information from the prime does not affect the decision processes which are mediated in part by central

inferential systems. So for instance, there was no indication that the lexical status of the prime influenced the judgment of the lexical status of the target, or that judgments concerning the identity of a pre-specified target were influenced by the nature of the prime.

From these results a picture of masked priming can be fashioned: When the prime is presented, it accesses (and opens) its appropriate entry in the mental lexicon, which then remains open for a short period of time. However, because of the action of the masks, the fact that the priming word occurred does not become a perceptual belief and so does not become an item considered by decision systems. When the target arrives, it accesses its appropriate entry, and if this is the same one as the prime has opened, then a benefit will accrue.

It is beyond the scope of this article to go into detail about the various research findings made using the masked priming technique, suffice to say that not only is the pattern of data obtained different from that obtained with the standard long-term unmasked version, (see Forster and Davis, 1984; Forster et al., 1987; Davis, Sánchez-Casas and García-Albea, 1991), but masked priming also appears to provide a new method of examining issues connected with the modularity debate. For instance, recently Forster and Davis (1991) have shown that the lexical decision and naming task (where the subject must pronounce the target string) seem to be differentially sensitive to an aspect of the masked stimulus. That is, unlike lexical decision, the naming response can be affected by the initial letter of the masked stimulus. One way of describing this difference in task sensitivity is in terms of the availability of information. It is argued that pronouncing a word may be a process sensitive to with in language module properties, whereas the lexical decision task (which involves central system decisions) is not.

In conclusion, the modularity thesis, with its notion of specialized processors feeding into more general ones, has provided a basis for questioning the interpretation of previous results based on repetition priming, and has also furnished the rationale for a new investigative technique.

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