

What kind of a framework?

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With any theoretical work that hovers between framework and model there are the twin dangers of not saying enough and saying too much. The not saying enough has to do with a kind of Gricean "never say more than you need to" which leaves all readers dissatisfied in the domain of their own speciality. The saying too much is a response to the need to illustrate general principles and leads to the danger that the reader believes that such is what the author believes, rather than such being the *type* of thing the author believes. Even being aware of this problem, the reader wonders whether the illustrations can be generalised without violating the spirit of the enterprise. I felt that Broadbent's article was particularly subject to these problems partly because of the fluidity of the switches between levels and partly because of the odd mixture of computational and everyday metaphors which typifies his theoretical work. There is always uncertainty as to the level at which to take them.

Before discussing some deeper issues I would like to make a technical point. Broadbent cites my own work (Morton 1969) as showing that additive effects can be at the same stage. There is a problem with this, however. The stages argument related solely to the influence of pairs of variables in the time taken for operations. The additivity in the logogen model relates to "evidence," and there are no simple predictions to be made from this to the time taken to make a decision. Even if there were, I would immediately appeal to one of Broadbent's warnings, that variables need not be involved in only one stage, or to put things in Broadbent's terms, variables may affect more than one process.

Codes in stores versus contingent properties. Broadbent's target article is evolutionary in its structure. We start with the four arms of the cross being characterised as "stores." These appear to be for sensory information, motor output programs, abstract material, and (long-term) associative information. In the final section of the paper, however, the four arms are being defined in terms of the contingencies that will change the representations; we have four *classes* of representation rather than four stores. The reasons for this switch of emphasis are clear. First, the distinctions end up being operational rather than, say, purely logical. Second, the first three arms turn out to have a number of separate components. Third, we find an evolution of processor function.

The processor is concerned with transfer from one arm of the cross to another. When the framework is introduced, this transfer is equated with "translation or change of coding." However, there is the qualification "typically" on this equation. Later, we learn that "[motor output programs] . . . can . . . be fed through the centre of the cross . . . to another and different set of motor programs." We also get the suspicion that such programs could be stored in the long-term store. All of this highlights the ambiguity in the name "abstract working memory" for the third arm, which is characterised as "nonsensory, nonmotor." Does Broadbent mean that sensory information cannot be held in working memory while particular computations are performed on it? There is a suspicion that this is not the case, but the text could be read either way. What is clear is that if there is sensory information in working memory then it is not subject to the same kind of interference as the same information in the sensory store would be. But these are not incompatible propositions.

Local computation and direct transfer. Two related problems concern the principles of whether the arms are allowed to have any computational power — separate, that is, from the central processor — and whether transfer can occur between the arms without involving the processor. Clearly the latter would entail the former. The problems can be illustrated by considering an alternative formulation.

Broadbent locates the processes associated with input logogens (Morton 1979) within the processing system. Input logogens are pattern recognition devices that categorise language inputs at the lexical level. The current logogen model also includes output logogens that are responsible for producing lexical outputs. I have proposed (e.g. Morton & Patterson 1980) that there are direct connections between input and output logogens that completely bypass any central processing. Part of the evidence for this is a patent reported by Schwartz, Saffran, and Marin (1980) who was able to read words aloud although unable to perform the simplest of semantic judgments. The natural, though no doubt not the only, way of translating these findings into the Maltese cross would be to give the sensory and motor arms some processing power and allow direct connection between them. To satisfy the conditions Broadbent has set up one would probably have to work through some interference paradigm. Suppose it turned out that such a sensory-motor transfer did not interfere with long-term to desk-top transfer? Then, Broadbent says, "the framework . . . could be modified." In this way we see that above the explicit form of the Maltese cross is a more abstract framework which contains the core of his proposals.

If processing were allowed in the arms then certain problems might be solved. Thus, Broadbent notes that lip-read stimuli and speech stimuli are mutually interfering inputs. "If processing were allowed in the arms, and if the classes of sensory memory were associated with the processes, then this mutual interference could be motivated by the observation that lip-read information is used by the speech-recognition process.

What do we know about the fourth arm? In one of the metaphors that Broadbent uses, the long-term store is likened to a "filing cabinet," in which he can place papers he wants to save. "This description carries with it overtones of necessary intentionality that I suspect Broadbent does not desire. For why should one "want to save" the transaction of making a semantic judgment on a word as in the typical "levels of processing" experiment he uses to illustrate the use of the long-term store? It would seem, rather, as if any transaction might be stored, though this is likely to be seen as an empirical issue.

Given an indeterminacy in the conditions of entry into the fourth arm, what of the nature of the information contained therein? Broadbent opts for "a running total of the number of times Event A and Event B have occurred together." Later we gather that these associations should be interpreted in terms of very small fragments in the sense of Jones (1978). But it seems clear that these are not *necessary* properties of long-term storage. If it turned out that there actually were structures other than bidirectionally associative fragments with varying strengths of connection, it would not actually affect the principle of the Maltese cross, as I understand Broadbent's intentions. **Frame work or framework.** It appears that the Maltese cross is a framework not in the sense simply of being a superordinate for a class of models but in the sense of being a way of looking at things. It encourages a particular approach of studying task interference; and it forces a separation of long-term storage in the processing system from the long-term storage of information in the fourth arm. It can't, in its most general sense, be falsified; it can only be challenged when, to use Broadbent's remarks on associationist theory, "the general language . . . [tends] to make it difficult to formulate certain problems."