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Facilitation in Word Recognition: Experiments Causing Change in the Logogen Model

John Morton

The logogen has been defined as the unit which makes a particular verbal response available from whatever source. The simplest theoretical position has been that it was responsible for facilitation and the word frequency effect through either the experience or the production of words. Thus, producing a word in response to a picture should have an effect equal to that of reading the word, on the subsequent visual duration threshold of the word. An experiment by Winnick and Daniel (1970) goes against this requirement. This experiment has been replicated, and other experiments indicate modality specificity in facilitation. These results force the adaptation to the theory of two input logogens and an output logogen to replace the original single structure. Experiments on facilitation of picture recognition indicate at least two relevant levels and a two-way independence of picture and word recognition.

The logogen model (Morton, 1964, 1968, 1969, 1978) has been evolved to account for (or in response to) a wide variety of phenomena in the area of word recognition. The focal part of the model, the logogen system, is made up of devices which are responsible for producing a phonological code whenever appropriate. The linguistic unit with which the logogen is concerned is, roughly, a word. Thus, if the word "chair" is spoken, if the letter sequence CHAIR is presented, if someone is asked to name the object or free associate to "table," or if the word arises in spontaneous speech, the same logogen is terminally responsible. Since it obviates the need for multiple representations of the phonological code for a word, this is clearly the most economical hypothesis.

The criterion of simplicity has been taken further. Not only is all output of a particular word the responsibility of the one element, but all inputs coincide on the same point (Figure 1). The Cognitive System subsumes all processing other than that specified in other parts of the model. Thus, given that a relevant context exists for understanding a stimulus word, the Cognitive System produces "semantic" information, which interacts positively in the Logogen System with the sensory information derived from the stimulus. In spontaneous speech all that is present is the semantic information which is sufficient to make a particular logogen produce its phonological output.

Differences in the recognisability of words are accounted for by saying that the logogens corresponding to common words require less information to make them produce an output; that is, they have lower criteria than uncommon words. These differences in criteria have been ascribed to logogen use. Thus it has been believed that words used a lot in spontaneous speech have lower visual duration thresholds (Daston, 1957). Also, experiments which mimic the word frequency effect by giving subjects differential experience of nonsense words and then testing the recognisability of these words show cross-modal transfer (Weissman & Crockett, 1957). In addition, the effects of such pretraining exert a strong influence on response production in the absence of any stimulus (Goldiamond & Hawkins, 1958).

All this information contributed to the logogen concept and is consistent with it. It is, then, a central part of the concept as it stood, that any use of the logogen will give rise to subsequent facilitation of its use. I have used this notion twice in evolving the model; once in its justification and once in extending it. The first use was of Neisser's (1954) experiment in which he pretrained subjects with either PHRASE or FRAYS and showed that the latter had no effect on the subsequent recognition of PHRASE. I interpreted this as showing that the definition of a logogen was not only the output code

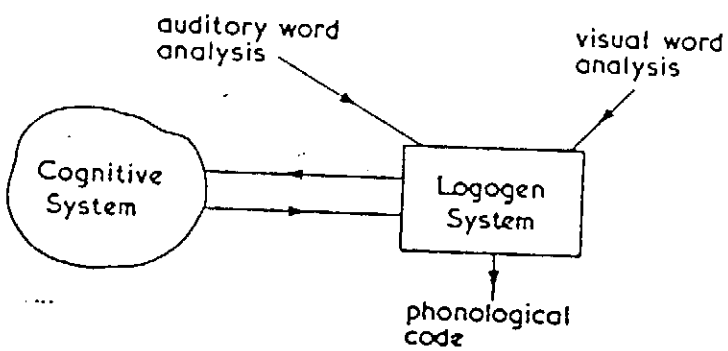

Figure 1. The essential parts of the original versions of the logogen model.

but also the visual or semantic codes that would be different for the two words. The second facilitation experiment was by Murrell and Morton (1974). In this study we showed that the subsequent recognition of BORED was affected by prior experience of BORING but not by more experience of BORN. The degree of visual and acoustic similarity between the practice and test words was equivalent; the difference was that BORING is morphologically related to BORED but BORN is not. Thus we concluded that logogens functioned at the level of the morpheme, not of the word as such. (It should be made clear that the morphemic identification is structural, not semantic. The logogen system is explicitly not a dictionary; I conceive semantic information as something to be discovered at a further stage when required.)

Winnick and Daniel (1970)

This position should have been badly weakened in 1970 when Winnick and Daniel published their paper. But somehow I managed to repress the implications of their study. In brief, they presented their subjects with a mixture of words, pictures of objects, and definitions of objects in which the object name did not occur. In all cases the subjects had to respond with the appropriate word. Later, all the words, plus controls with which no prior experience was associated, were presented for tachistoscopic recognition. The prediction from the logogen model is clear - the recognition of all the words should be facilitated with respect to the controls regardless of whether the words had previously been seen. In all three cases, within the existing logogen structure, if the response was made the logogen was used and so there must have been facilitation. In fact the mean tachistoscopic thresholds for the four groups of words are given in Table 1a. There were no differences apparent other than between the WORD group and the other groups. When I reread their paper last year, I realised I either had to find a flaw in their procedure or change my ideas. With this in mind I have participated in three series of experiments in the last year with Bob Clark, Clive Warren, and Anita Jackson. To anticipate the results, we replicated Winnick and Daniel's findings and extended the range of non-facilitation, and I have been forced to change the form of the model.

Facilitation of Visual Word Recognition

Experiment 1

In a pilot experiment Bob Clarke and I confirmed Winnick and Daniel's findings. The subjects were required to say words in response to the printed word, the picture, or a definition prior to a word threshold measurement. With very few subjects (n = 9) it became apparent that the basic results were being reproduced. The mean thresholds are given in Table 1b. The higher times are due to contrast, word size, and other factors which were different from those in Winnick and Daniel's study. It is clear that experience of neither pictures nor definitions had any effect on the subsequent recognition of the equivalent words. If just the pictures had given this result, it might have been argued that they were a special case, and that the phonological codes for object names were duplicated, once in the word system and once in the object recognition system. However, there is no such possibility in the case of definitions, for which no such special pleading is feasible.

Table 1(a). Winnick and Daniel (1970) Results.

Type of Pretraining	Words	Pictures	Definitions	Controls
Mean Threshold (msec)	49.1	58.6	61.0	61.9

Table 1(b). Experiment 1, Winnick and Daniel Replication.

Pretraining	Words	Pictures	Definitions	Controls
Threshold (msec)	111	118	121.5	123.6

We seem to be forced into a position such as that illustrated in Figure 2. In this case the facilitation is the responsibility of the visual input system. When a word is presented, analysed information passes into this input system and the appropriate logogen is activated. The word can then be produced as a response either through a direct connection to the output system (if such a connection exists) or through the Cognitive System. The logogen in the input system then has a lower threshold in the second part of the experiment and the standard facilitation effect is found. The picture (of a butterfly, for example) will be processed in a separate system. After being classified, I assume, some semantic code is accessed in the Cognitive System. This code is then translated into a phonological code in the output system. The logogen for "butterfly" in the input system would not be affected by this sequence of events. Thus we would find no subsequent facilitation in visual word recognition. (Note that if the word were spoken out loud and fed back via the ears, and if this acoustic input affected the same system, then there would be effects. But see on.) Similarly, although a definition of "butterfly" would be processed through the language processing system, the input logogen for the word would not be affected. The information in the definition would be computed upon in the Cognitive System and the response would be produced via the output system only. Figure 2 is thus consistent with the data and, given certain presuppositions, seems to be entailed by it. The data also require that there is no facilitation in the input system over the time intervals found in this experiment.

The account given by Winnick and Daniel favoured facilitation by repetition of stimulus patterns. The result of Murrell and Morton mentioned above, where the morpheme was seen to be the base of the facilitation effect, argues against that. Experiment 2 was conducted to verify this.

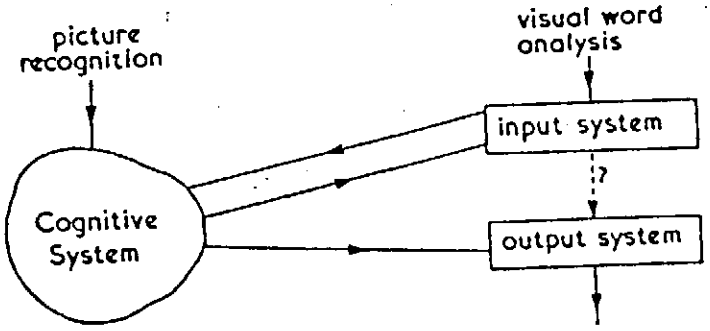

Figure 2. The minimum modification to Figure 1 forced by the results of Winnick and Daniel and Experiment 1. Only visual inputs are considered.

Experiment 2

The basic design was identical to the previous experiment. In this case the picture condition was dropped and a condition substituted in which the pretraining was a handwritten version of a word later to be seen in typewritten form. Care was taken to make the writing cursive so that although it could not be read letter for letter, it was still readable as a word. The other conditions were the typewritten word, the definition, and a control condition as before. This time the experimental procedure was more tightly controlled and the results were clear (Table 2).

The difference between typewritten and handwritten was not significant even at the 0.05 level. I am not going to argue that there is no difference there, simply that if there is one it is not at the level of the input logogen system. As before, the definitions had zero effect, the mean threshold being indistinguishable from that for the control group.

This result reinforces our belief in the correctness of the model in Figure 2. The facilitation effects are due to verbal inputs only. The next question is whether auditory and visual inputs affect the same system.

Table 2. Experiment 2 on Visual Recognition.

Pretraining	Typewritten	Handwritten	Definitions	Controls
Threshold (msec)	28.9	30.7	35.5	35.6

Table 3. Experiment 3 on Visual Recognition.

Pretraining	Visual repeat	Visual opposite	Auditory repeat	Auditory opposite	Control
	39.3	40.2	43.4	44.3	46.2

Experiment 3

In this experiment the pretraining was either visual or auditory. The recognition in the second part of the experiment was always visually based. A second variable, the nature of the response, was inserted into the pretraining. As each word was presented, the subject was instructed either to read or repeat the word (for visual and auditory presentation respectively), or to give the opposite. Stimuli were either polar adjectives like "hot" or "wide" or were nouns such as "queen" or "uncle," where the spontaneous opposite response always involved a gender change. This variable was introduced because we thought it possible that facilitation would only be found if the link posited tentatively between the input and output systems was used. If the subjects were required to give an opposite, this link would less likely be involved. (Of course this was a heavily contingent prediction - the negative result would prove nothing.)

From the data given in Table 3, it is clear that the nature of the response was immaterial. It is also clear that the modality of the pretraining did make a difference. There is no significant difference between the auditory conditions and the control, but we don't want to insist there is no difference. Suffice it here to say that we feel it necessary to talk in terms of two input logogens, one for each modality. Thus we have a model which in simplified form is shown in Figure 3. We can see now why no facilitation would be expected following feedback of someone naming a picture out loud. There are no connections between the two input systems, and any facilitation is restricted to the modality being tested. (This is the strongest form of the new model and is liable to falsification.)

Facilitation of Auditory Word Recognition

One alternative to Figure 3 is a model in which the visual input system feeds into the auditory input system, but not vice versa. This is demonstrated in an abbreviated form in Figure 4. This would be consistent with the previous data, but would give rise to the prediction that experience of visual words will facilitate subsequent recognition of auditorily presented words.

In this experiment Anita Jackson and I used a separate groups design where each subject received only one kind of pretraining. The pretraining consisted of the subjects making semantic judgments on a list of 100 words, which was

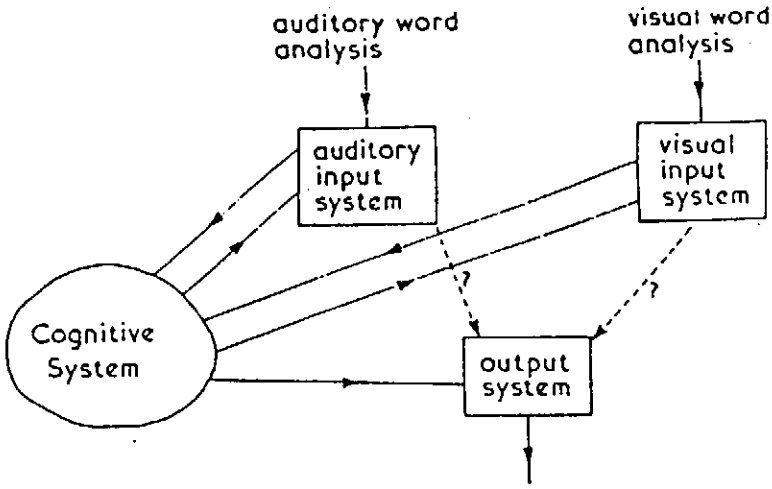

Figure 3. The elaboration of the model of Figure 2 to allow for auditory verbal stimuli.

presented twice. The subjects then heard a sequence of 200 words including the 100 which had been pretrained. These words were presented in white noise adjusted to give 40% correct identification with control subjects. There were four groups of interest for the present discussion, differing by the nature of the pretraining. One group had previously heard the test words spoken in the same clear female voice as that used in the recognition session. A second group had also heard the words previously, but in a male voice. The third group had seen the words, rather than heard them, and the fourth was a control group which went through the recognition session with no prior experience of the words. The results are given in Table 4. The figures represent the mean probability of correctly recognising a word in the pretraining set and the control set. The results are complicated by the fact that there are differences in performance for the untrained words between subject groups similar to the difference found between the pretrained words. When suitable

Table 4. The Effects of Different Prior Experience on Auditory Recognition.

Pretraining		Same voice	Different voice	Visual	Control
Prob. correct for:	Experimental words	.60	.51	.41	.33
	Control words	.49	.45	.44	.40

Table 5. Effects of Prior Experience on Picture Recognition—Experiment 1.

Pretraining	Same picture	Different picture	Words	Control
Threshold	35.7	40.9	43.6	43.8

adjustments are made, it is found that the effect of visual pretraining is just significantly different from the control group, but that the two groups with prior auditory experience, while not differing from each other, were very different from both the visual and control groups.

These results parallel those found with visual presentation. There is a small cross-modal effect and small differences within modality but the main thrust of the data favours the representation in Figure 3. Experience of a word affects the input logogen specific to the modality of presentation. Other effects and differences are smaller in magnitude and we expect to be able to attribute them to other causes.

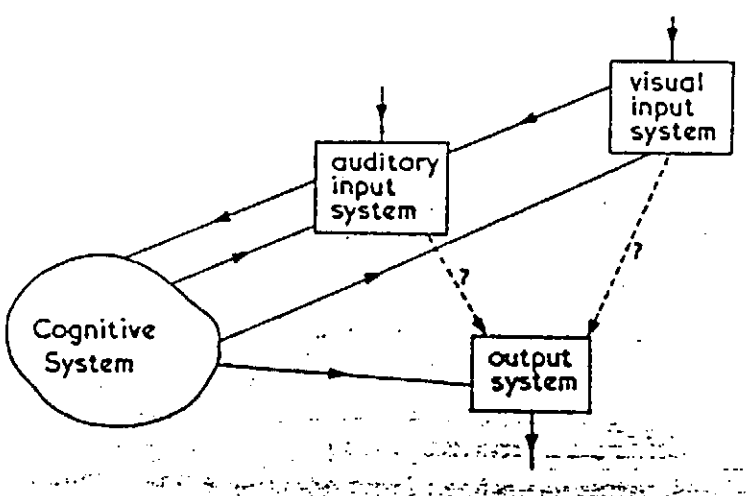

Figure 4. An alternative model consistent with the data from the first three experiments. The data presented in Table 4 force us to reject this alternative.

Facilitation of Picture Recognition

In a previous section I noted that Clark and Morton had replicated Winnick and Daniel's finding that naming pictures does not affect subsequent recognition of words. In this series of experiments by Clive Warren and me, the design was reversed and the question was posed as to the influences on picture recognition.

Experiment 1

There were two parts of interest. The first involved the subjects reading words or naming drawings of objects, and the second involved the tachistoscopic recognition of drawings. These drawings were of objects named by the words in the preceding session, or were drawings previously named, or different drawings of objects which had previously been named. Table 5 gives the mean thresholds of recognition.

It is clear that experience with the words has no effect on picture recognition. In light of the results already reported, this will come as no surprise. It is also apparent that experience of a specific drawing facilitates subsequent recognition of the same drawing. The question of transfer to a different picture of the same object is less clear. When questioned, a number of subjects revealed that they had been adopting the strategy of attempting literal recall of the pretraining drawings and matching them against the stimuli. This was possible because only eight drawings were used in the pretraining.

Experiment 2

Forty-four drawings were used in the pretraining - eight were later seen in the recognition session with eight different drawings of previously named drawings of objects, plus drawings for which there had been no relevant prior experience. The effect of these changes in procedure was a significant transfer from one picture of an object to another picture of the same object. The figures can be seen in Table 6.

Other evidence in this study has led us to believe that there are two sources of facilitation in picture recognition. The first is reactivation of a literal representation of a drawing; the second is a more abstract, idealised centre for each object type. This might be termed a "pictogen." The object recognition system, up to and including the pictogens, does not intersect the system

Table 6. Effects of Prior Experience on Picture Recognition--Experiment 2.

Pretraining	Same picture	Different picture	Control
Threshold	35.8	39.4	43.2

involved in word repetition.

Conclusions

The new form of the model has replaced the old logogen system with three elements: visual input logogens, auditory input logogens, and output logogens. The picture recognition system is completely separate. All the earlier results are still applicable to the model, usually to the input logogens. Apparent cases of cross-modal transfer are the exception (e.g., Weissman & Crockett, 1957). Such results would now be attributed to problem solving behaviour using information in the cognitive system (something like an episode related to the pretraining). The replacement of one construct by three others has added enormous power. The new formulation has something in common with recent proposals by Seymour (1975), Shallice (personal communication) and Marcel and Patterson (1978).

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