# 2 THE ROLE OF MEANING IN WORD RECOGNITION

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## INTRODUCTION

The goal of the present discussion is to bring into focus a number of implicit assumptions in the area of word recognition research (see also Seidenberg, this volume). These assumptions revolve around what will here be referred to as the magic moment in word processing. The magic moment refers to that point in time where the subject has recognized the word but has yet to access meaning. Researchers have argued that they can both collect data and develop adequate models of this crucial point in word processing. The outline for this chapter is as follows: First, the empirical support for a magic moment is evaluated. The thrust of this discussion is that the major tasks used to provide data regarding the magic moment entail characteristics that question their utility as pure reflections of this crucial point in word processing. Second, an alternative framework is presented that emphasizes the functional utility of words in language processing, that is, to convey meaning. Third, empirical evidence is presented that suggests that meaning can contribute to components involved in early word processing. Finally, there is a brief discussion of how meaning might be incorporated into the current theoretical accounts of word processing.

## THE MAGIC MOMENT IN WORD PROCESSING

If one considers the classic models of word recognition proposed by Becker (1980), Forster (1979), and Morton (1969), among others (e.g., Norris, 1986), there is consistent emphasis on a point in time where there is sufficient overlap between stimulus-driven information and some internal lexical representation that the subject recognizes the word. For example, within Morton's logogen model this magic moment is the point in time where a logogen's threshold is surpassed. Within Becker's verification model, this magic moment is when there is sufficient overlap with a sensory-defined internal representation and the information residing in sensory memory about the stimulus word. In Forster's bin model, the magic moment refers to the point in time where there is a sufficient match between an orthographic representation derived from operations on the stimulus word and a representation in an orthographically defined access bin. In each of these models, it is only after this magic moment in word processing that the subject can access the goodies associated with the word, for example, meaning and syntactic class.

It should be noted that the description just given primarily involves isolated word recognition and cases where words are presented in unrelated contexts. When words are presented in related contexts, meaning of a word may become available before the word is recognized, via priming from related representations. Although meaning may actually contribute to word recognition when relevant context is preactivated, meaning of a word that is not preactivated by related context will not contribute to word recognition within these models. Moreover, even in cases where relevant meaning is preactivated, word recognition in each of the earlier mentioned models still involves a magic moment in word processing.

Psychologists have relied heavily on the lexical decision task (LDT) and the pronunciation task to tap this crucial point in word processing. Based on the arguments made from the data obtained from these tasks, it would appear that researchers in the area of word recognition are in the comfortable position of having tasks available that decouple word recognition from meaning access. Unfortunately, this comfortable position is deceptive.

## Surface-Level Descriptions

On the surface, both the LDT and the pronunciation task seem to be faithful reflections of the magic moment. For example, making a lexical decision seems to involve the point in time when an internal representation has been matched by stimulus-driven information, and, therefore, the meaning of the word seems unnecessary. Thus, the button press in the LDT appears to be a reasonable reflection of the magic moment. In addition, it appears that naming a word simply involves a match between stimulus-driven processing of the word and some lexical representation. Once this match is completed, the appropriate sequence of motor codes is engaged for output. Thus, onset of pronunciation, on the surface, also appears to be a reasonable reflection of the magic moment.

Before turning to a more detailed discussion of these tasks, it might be worthwhile to ask whether the use of a response latency measure helps to promote the notion of a measurable magic moment in word processing. That is, the magic moment is that point in time when the subject decides to press a button or begins vocalization. Thus, the researcher has a characteristic of performance that can be mapped onto a temporally defined stage in processing. The availability of response latency measures might mislead one into accepting isolable stages in processing instead of a more cascadic processing framework (McClelland, 1979).

One of the major goals of the present discussion is to look beyond the surface-level descriptions of lexical decision and pronunciation performance. It is important to note here that the present arguments are primarily aimed at the relevance of these tasks to the magic moment hypothesis in word processing and not at their general relevance to research addressing issues involved in pattern recognition, word processing, and attention. Thus, the intention is not to dismiss all data from these tasks but simply to question the purity of these tasks as reflections of the magic moment.

## Beyond the Surface in Lexical Decision Performance

First, let us consider a deeper analysis of the LDT. The literature is now replete with concerns about its utility as a measure of the magic moment (e.g., Balota & Chumbley, 1984; Balota & Lorch, 1986; Besner & McCann, 1987; Chumbley & Balota, 1984; De Groot, 1983; Keefe & Neely, in press; Lorch, Balota, & Stamm, 1986; Neely & Keefe, 1989; Neely, Keefe, & Ross, 1989; Seidenberg, Waters, Sanders, & Langer, 1984; West & Stanovich, 1982). The major problem with this task is that the surface-level account ignores the fact that this task is not simply an identification task but rather is a discrimination task in which subjects are forced to discriminate words from nonwords. Subjects can rely on any source of information that is available to make such discriminations. The present discussion simply emphasizes the fact that some variables that presumably influence processing up to the magic moment also could reflect the influence of a confounding between the manipulated variable and the discrimination the subject is required to make.

### Isolated Lexical Decisions

First, let us consider lexical decision trials on which only a single word is presented. There are at least two sources of information that would appear to be especially useful in discriminating words from nonwords (Balota & Chumbley, 1984; Besner & McCann, 1987; Chumbley & Balota, 1984): familiarity and meaningfulness. Very simply, words are more familiar and meaningful than nonwords.

With respect to the familiarity dimension, Balota and Chumbley (1984) reported the results of a series of experiments that directly compared the size of the frequency (an obvious correlate of familiarity) effect in lexical decision, category verification, and pronunciation performance for the same set of stimuli. The authors argued that all of these tasks, as viewed by the extant theories, should involve lexical access. Therefore, if word frequency modulates only lexical access processing, then these tasks should produce a similar impact of frequency. However, the results of Balota and Chumbley's study (also see Chumbley & Balota, 1984) indicated that the category verification task produced a significantly smaller influence of frequency than the LDT. The relatively small impact of frequency in the category verification task was not simply due to idiosyncratic characteristics of the Balota and Chumbley study, because similar small influences of frequency have been reported in other experimental situations where performance a priori should be influenced by variables that influence lexical access (e.g., Anderson & Reder, 1974; Brown, Carr, & Chaderjian, 1987; De Groot, 1989; Forster, 1985; Günther, Gfroerer, & Weiss, 1984; Kliegl, Olson, & Davidson, 1982; Manelis, 1977; Millward, Rice, & Corbett, 1975).

Why is the frequency effect so large in the lexical decision task? Basically, there is a confounding between the manipulated variable, frequency/familiarity, and the word/nonword discrimination demanded by the task. Low-frequency words are more similar to nonwords on the relevant familiarity dimension than are high-frequency words. Thus, low frequency words are more difficult to discriminate from nonwords than are high-frequency words. This increased difficulty in discrimination slows response latency. It is important to note here that Balota and Chumbley did not argue that word frequency did not influence early operations in word processing. The major point made in their study is that one cannot unequivocally argue that the impact of frequency in lexical decision performance is only due to processes leading up to and including the magic moment in word processing.

The impact of the discrimination component on the size of the frequency effect is further supported by data from Duchek and Neely (1989) and James (1975). These studies provide evidence that the frequency effect is decreased when the nonwords become less "word-like," for example, making the nonwords unpronounceable. This, of course, would be expected if recognition of low-frequency words is slowed down by their similarity to the nonword distractors. When this similarity is decreased, via the presentation of unpronounceable nonwords, one finds that the low-frequency words benefit more than the high-frequency words from this increased ease in discrimination. The major point here is that the discrimination is modulating the frequency effect, not simply lexical access.

Finally, it should be noted that although familiarity values are available to subjects, it does not *necessarily* follow that in the LDT they modulate lexical access processes. In order to further illustrate this point, consider the hypothesis that subjects are faster to recognize words printed in red compared to words printed in purple. To test this hypothesis, red and purple words along with blue nonwords are presented in a LDT. The results support the hypothesis. The words printed in red produce faster response latencies than the words printed in purple. The obvious interpretive problem here is that the purple words are more difficult to discriminate from the blue nonwords than the red words. Thus, the obtained pattern does not necessarily reflect the fact that color is influencing lexical access but rather that color is a dimension available to subjects and this dimension is influencing the decision process. We are simply making a similar argument with respect to familiarity.

**Priming Lexical Decisions**

Turning to the priming paradigm, here two letter strings are typically presented. The first string is often a word and the second string is either a word or a nonword. The experimenter manipulates the relationship between the first word and the second string. For example, in a semantic priming experiment, subjects might receive semantically related prime-target pairs (e.g., *dog* - *cat*) or unrelated prime-target pairs (e.g., *pen* - *cat*). The basic finding here is that subjects are faster to recognize words (i.e., press the word button) that are primed by related words compared to words primed by unrelated words (e.g., Meyer & Schvaneveldt, 1971; Neely, 1977). This priming effect has been viewed as supportive of the notion that the related prime preactivates or directs the search to the target's lexical representation, thereby decreasing the time taken to recognize that word (see, however, Ratcliff & McKoon, 1988). Priming effects have been the focus of considerable attention in virtually all models of word recognition (e.g., Becker, 1980; Forster, 1981; Norris, 1986).

Unfortunately, it has become clear that there are influences of prime-target relationships in the LDT that do not necessarily reflect the directional impact of the prime on target processing (e.g., Balota & Lorch, 1986; De Groot, 1983; Forster, 1981; Keefe & Neely, in press; Lorch et al., 1986; Lupker, 1984; McNamara & Altarriba, 1988; Neely & Keefe, 1989; Neely et al., 1989; Seidenberg et al., 1984; West & Stanovich, 1982). There again appears to be a simple confounding in this task between the manipulation (prime–target relatedness) and the discrimination (word - nonword) that the subject is making. The argument is that subjects could rely on finding a relationship between the prime and target to bias a "word" response. If the subject finds a relationship between the prime and target, then the target must be a word, because nonwords cannot be related to the primes. However, if no relationship is found between the prime and target, then the target could either be a nonword or an unrelated target. Thus, on unrelated prime-target trials, subjects are faced with a more difficult word - nonword discrimination than on related prime-target trials. Hence, it appears that checking for a relationship after the magic moment may influence the priming effects found in the LDT. It is somewhat encouraging that researchers have recently begun to develop procedures to address this problem and modulate the reliance on such checking processes (see Keefe & Neely, in press; McNamara & Altarriba, 1988; Neely et al., 1989).

In sum, the major point to note concerning the LDT is that there is often a confounding between the manipulation of interest and the information that the subject can use to make the word - nonword discrimination. Subjects are very sensitive to such confoundings (see Chumbley & Balota, 1984), and these confoundings can produce exaggerated influences of variables, thereby misdirecting theories of word recognition. Most importantly, for the present discussion, these confoundings question the utility of the LDT to measure the magic moment in word processing.

## Beyond the Surface in Pronunciation

On the surface it would appear that pronunciation is more straightforward. Here, the subject is not asked to make a discrimination between words and nonwords and therefore there should be little contribution of a potentially contaminated decision process on overall response latency. Thus, the magic moment of matching stimulus-driven information with an internal lexical representation might be better reflected in this task. However, even in the pronunciation task a variable could potentially play a role at many different loci in this task, thereby also questioning the utility of this task for providing unequivocal evidence concerning processes leading up to the magic moment.

### Isolated Pronunciation

The basic concern with the pronunciation task was voiced originally by Cattell (1886). In pronouncing a word, the subject not only has to recognize the stimulus but also has to output the recognized word. Thus, a variable could have an impact on recognition processes and/or on processes after recognition that are tied to the output of the response. Consider the impact of word frequency. Balota and Chumbley (1985) used a delayed-pronunciation task to tease apart the impact of frequency on word recognition from its impact on output processes. In the delayed-pronunciation task, subjects are given sufficient time to recognize the word and then are presented a cue to pronounce the word aloud. If frequency only influences the recognition stage in this task, then one should not find a frequency effect after subjects have had sufficient time to recognize the stimulus. Balota and Chumbley found that subjects still produced a significant frequency effect in this task, even though they were given up to 1400 ms to recognize the stimulus. Because 1400 ms should clearly be sufficient time to recognize a word, they argued that frequency must play at least some role in processing after word recognition. More recently, Balota and Shields (1988) have replicated this pattern with a new set of stimuli that were better equated on (a) beginning and ending phonemes, (b) number of phonemes, (c) number of syllables, and (d) syntactic class. Interestingly, not only did Balota and Shields replicate the delayed pronunciation frequency effect, but they also provided evidence for an impact of frequency on the production durations of these stimuli. Low-frequency words produced longer production durations than high-frequency words.

The impact of word frequency on output processes should not be surprising. If frequency of usage has an impact on the perception of words, it is unclear why frequency of usage would not also have an impact on processes involved in the production of words. Balota and Chumbley (1985) argued that because of the time constraints in producing speech versus writing, the range of frequency in producing speech might actually be smaller than the range of frequency in print. Because speakers have temporal constraints in production, they might be less likely to take the necessary time to search for an obscure word to perfectly convey a given meaning, whereas, writers, because they don't have the same temporal constraints, can pause to complete the search for a relatively obscure word to convey a given meaning. Moreover, finding such a perfect word in writing may be more important because there is not interactive feedback from the recipient of the message, as there is in speech. Thus, because of these potential differences in the range of frequency in speech production versus writing, one might actually expect a larger frequency effect in the output processes involved in pronunciation compared to the word recognition processes involved in pronunciation. Unfortunately, because of the current paucity of detailed production frequency norms, this argument can only take the form of a functional assessment of the temporal constraints in writing and producing speech.

### Priming Pronunciations

Now, consider the impact of prime-target manipulations on pronunciation performance. Recently, Balota et al. (1989) have demonstrated that prime-target associations can influence both onset latencies and production durations in a delayed-pronunciation task. For example, in one of their experiments, they reported that subjects were faster to begin their production of two related words, compared to two unrelated words, even though they had 1400 ms to recognize the stimuli (also see Dallas & Merikle, 1976; Midgley-West, 1979). Moreover, they found that the production durations were shorter for related words than unrelated words. Because 1400 ms should be sufficient to recognize two words, it is unclear how one can unequivocally attribute the priming effect in pronunciation performance to the magic moment. The theoretical implication of this finding is that any extra activation due to the relationship between two words can influence performance throughout the processing system (also see Shields & Balota, 1988).

In sum, the important point for the present discussion is that because variables appear to influence processes after subjects have sufficient time to recognize the stimulus, one cannot unequivocally attribute the influence of a variable in the pronunciation task to processes leading up to the magic moment in word processing.

## Other Measures

The emphasis in the present discussion addresses the utility of the pronunciation task and the LDT as windows into the magic moment. The emphasis on these tasks is necessary because they have provided the primary source of data for models of word recognition. However, it should be noted that there are other measures of the magic moment available. For example, some have argued that threshold identification can provide a window to the magic moment (e.g., Broadbent, 1967; Humphreys, Evett, Quinlan, & Besner, 1987; Tulving & Gold, 1963). Although such research has provided some intriguing findings, there is the potential problem that in an untimed paradigm subjects can rely on domains of knowledge in a sophisticated-guessing fashion to identify the degraded stimuli. These domains may not be the same domains that are used in fluent reading. Hence, one must also question the utility of the threshold identification task as a window to the magic moment in word processing (see Catlin, 1969, 1973).

A better window to the magic moment might entail on-line measures (fixation and gaze durations) during reading. Here, the subject is engaged in a more natural task that does not have the problem of directing the processing system to a domain of knowledge that is in some sense peculiar to the task demands. This is an important advantage. However, even in this task, one cannot use the data to support the magic moment hypothesis. It is clear from the work of Rayner and colleagues that meaning and integration processes can occur very early in word processing and can carry over into subsequent fixations (Balota, Pollatsek, & Rayner, 1985; Ehrlich & Rayner, 1983; Frazier & Rayner, 1982; Rayner, Carlson, & Frazier, 1983). Thus, fixation duration on a given word cannot be used as a pure indicant of the magic moment. Pollatsek and Rayner (this volume) and Rayner and Balota (1989) provide a more detailed discussion of the use of fixation times as a measure of word recognition processes.

## WHAT'S THE ALTERNATIVE?

The major thrust of the discussion just presented is that superficial descriptions of the major tasks used to provide data concerning the magic moment in word processing can be misleading. In particular, a deeper consideration of the two major tasks, lexical decision and pronunciation, indicates that both tasks involve components that clearly question their utility as windows into the magic moment.

However, what's the alternative? It would appear that at some level there must be a lexical identification process that leads to meaning analysis. How could one analyze the meaning of a stimulus without knowing the identity of the stimulus? Thus, again on the surface level, there appears to be a necessary step of word recognition prior to meaning access.

Although it is clear that some level of visual analysis must precede meaning access, it does not necessarily follow that word recognition in the sense emphasized in the models of word recognition is a logical prerequisite for meaning analysis. It is possible that meaning analysis occurs relatively early in word processing and in fact might contribute to word recognition in the sense emphasized by the models. If this were the case, then one might argue for a more prominent role of meaning in word recognition.

There are two general arguments in favor of a more prominent role for meaning in models of word recognition. The first argument emphasizes the functional role of words in language, and the second is based on empirical evidence that suggests that meaning can play an early role in word processing.

## THE FUNCTIONAL ROLE OF WORDS IN LANGUAGE

Obviously, the functional role of words in language is to convey meaning. However, in tasks used to investigate word recognition processes (lexical decision and pronunciation), meaning presumably plays little functional role. This difference in emphasis on meaning between tasks that are used to investigate word recognition and the task of more natural language processing may be quite important. This is especially noteworthy in light of arguments concerning transfer-appropriate processing (Durgunoğlu & Roediger, 1987; Jacoby & Witherspoon, 1982; Kolers & Brison, 1984; Kolers & Paradis, 1980; Kolers & Roediger, 1984; Morris, Bransford, & Franks, 1977). According to the transfer-appropriate processing framework, a stimulus may be coded in many different forms based on an individual's expectations, available skills, and the particular task demands. Specific tasks may differentially emphasize different subsets of these codes. Thus, the representations that play a functional role in speeded lexical decision and pronunciation may not be the same representations that play a functional role in more natural language processing.

The importance of the transfer-appropriate processing approach has been nicely illustrated by Durgunoğlu and Roediger (1987). These authors addressed the evidence concerning the debate over language-independent and language-dependent representational systems in bilinguals. In reviewing the literature, they suggested that one typically finds evidence for language-independent performance in conceptually-driven tasks such as free recall, whereas one finds evidence for language-dependent performance in more data-driven tasks such as lexical decision and fragment completion. In the past, researchers have simply been led to different conclusions across these studies regarding single- versus dual-code representations. Durgunoğlu and Roediger replicated this basic pattern in a single experiment. They found that the language of an earlier presentation of a word (i.e., either English or Spanish) was crucial in determining later fragment completion performance (in English), whereas this had no impact on later recall performance. In addition, they found that conceptual processing of a word (e.g., forming an image or translating a word into a different language) had a substantial impact on free recall performance but had very little impact on fragment-completion performance. Thus, based on the fragment completion results, one would argue for a language-dependent representational model, whereas, based on the free-recall results, one would argue for a language-independent representational model.

In accounting for their data, Durgunoğlu and Roediger made a distinction between tasks that tap conceptually-driven operations and tasks that tap data-driven operations. The distinction between conceptually-driven and data-driven tasks and transfer-appropriate processing is clearly relevant to the present discussion. Very simply, the tasks (i.e., LDT and pronunciation) used to build models of word recognition are more data-driven, whereas the task of comprehending words in language processing is more conceptually driven. As the Durgunoğlu and Roediger results nicely illustrate, a variable can have quite different impacts across such domains of tasks. Thus, if one wishes to develop adequate models of word recognition, then the tasks that are used to build such models should contain a functional role for meaning analysis. This is precisely why eye-tracking records during reading for meaning may eventually provide the best window into word processing.

## EMPIRICAL EVIDENCE

In addition to the functional appeal for a more prominent role of meaning in word recognition, there is also empirical evidence that suggests that meaning can influence early perceptual processing. This evidence takes two forms. First, there is evidence which will be referred to as decoupling evidence. The basic form of this evidence is that meaning can influence performance even though the subject cannot, in some sense, recognize the stimulus. The second line of evidence is more direct. In this research, there is evidence that meaning can directly influence early perceptual operations in word processing. It is important to point out here, however, that there may be alternative accounts of aspects of this evidence for the notion that meaning can influence early processing in words.

### Decoupling Meaning from Word Recognition

The research discussed in this section suggests that meaning can influence performance even though the subject cannot recognize the stimulus word, at least as indicated by correctly naming the stimulus word aloud. Thus, the strict serial dependency on word recognition, as indicated by accurate naming, before the access of meaning is called into question. As to be described, there are two distinct lines of research that provide evidence for meaning access without explicit recognition of the stimulus word.

### Threshold Priming

First, consider the threshold priming literature. Here, one finds that even though subjects cannot make above-chance presence/absence detection decisions about a prime word, there is still evidence of meaning access (Balota, 1983; Fowler, Wolford, Slade, & Tassinary, 1981; Marcel, 1983). That is, subjects are faster to recognize the word *dog* when it follows *cat* than when it follows *pen* even under masking conditions that yield chance presence/absence detection performance on the prime items. One possible account for this pattern of data is that there may be multiple codes that are activated upon word presentation. These codes might involve at least the three basic types of information that subjects have available for a visual stimulus word, that is, its meaning, its sound, and its visual form. The threshold-priming experiments could be viewed as indicating that the visual form code can be disrupted by a pattern mask even though the meaning code is still accessed. The importance of the visual form code is that without such a code the subject cannot consciously report that a visual stimulus was presented. The threshold-priming situation suggests that meaning can be accessed in situations where the subject cannot provide direct evidence of word recognition. Hence, it appears that meaning may be available very early on in word processing.

It should be noted that there is some debate in the literature concerning threshold priming. This debate centers around the issue of whether researchers have obtained an accurate estimate of presence/absence detection thresholds (see Holender, 1986, for a detailed discussion). Even if subjects were not at a detection level threshold in the already cited studies, it is unlikely that subjects were at a level of visual analysis that would yield accurate lexical decision or pronunciation performance. That is, if subjects have difficulty indicating whether something or nothing was presented on a given trial, then it is unlikely that they could make a lexical decision or correctly pronounce the word aloud. If this analysis is correct, then these results suggest that meaning can be accessed before sufficient information is obtained to produce lexical access as measured by lexical decision and pronunciation performance. This obviously runs counter to the suggestion that these tasks are a reflection of a premeaning access component of word recognition. It appears that meaning can be accessed very early and without the full visual record of the stimulus available for conscious report.

### Deep Dyslexia

A second line of research suggesting that meaning can be accessed even though subjects do not have sufficient information available for accurate identification is the evidence from aphasic individuals exhibiting the syndrome referred to as *deep dyslexia*. Deep dyslexics are individuals that produce an interesting type of semantic error in output. For example, when presented with the word *dog*, such individuals might produce the word "cat" instead of the appropriate response "dog." Other types of errors are also produced. For example, these individuals exhibit (a) derivational errors (e.g., *mercy* for *merciful*), (b) visual errors (e.g., *puddle* for *puppy*), and (c) considerable difficulty producing nonsense strings.

For the present purposes, we focus on the semantic errors. As a number of researchers have argued (e.g., Marshall & Newcombe, 1980; Shallice & Warrington, 1980), such effects can be accounted for by arguing that there is a breakdown in a nonlexical grapheme-to-phoneme output system. The notion is that there is a direct route to the lexical/semantic system and also routes that correspond to visual-to-grapheme correspondences and grapheme-to-phoneme correspondences. Presumably, the direct route is intact and therefore activates lexical/semantic representations. These representations produce a spread of activation to related areas in the system. Assuming some noise in the system, it is possible that a lexical representation that is semantically related to the letter string is sometimes output instead of the actual letter string. Newcombe and Marshall argue that the extra feedback from the grapheme-to-phoneme correspondence route serves to eliminate such errors in output. However, because this system is deficient for the deep dyslexics, there is no extra stabilization from these routes to minimize such errors. Thus, one finds on some trials the output of a semantically related word, even though that word is not visually related to the target word.

What's the relevance of this finding to the present discussion? First, such semantic output errors again provide a situation where there is a decoupling of meaning from recognition, as indicated by accurate naming. In some sense, the subject has accessed meaning but cannot identify the presented word. Second, the pattern of errors produced by these individuals also reflects syntactic-class distinctions. For example, these individuals are more likely to read concrete nouns correctly, followed by verbs, adjectives, and abstract nouns. Function words produce the greatest number of errors. The importance of these differences is that it appears that at some level the syntactic characteristics (along with other meaning-level differences such as concreteness) influence the probability that the word is correctly output. These patterns of errors are difficult to reconcile with a pre-meaning, pre-syntactic magic moment in word processing.

## Direct Influences of Meaning on Perception

Recently, there have appeared a series of experiments that could be viewed as suggesting that the meaning available for a stimulus can influence lower-level perceptual processes. First, consider a recent series of experiments by Whittlesea and Cantwell (1987). For the present purposes, we focus on their third experiment. In this experiment, the materials consisted of 24 pronounceable five-letter nonwords. Half of these nonwords were assigned meaning, whereas the remaining half were presented in a perceptual letter-checking task to equate simple visual processing. The items that were assigned meaning corresponded to lexical gaps. That is, the meanings were such that there was no common word that already involved the proposed meaning, for example, *walen* was defined as "the sound that a dam makes before breaking." After the visual-processing and meaning-assignment tasks, the nonwords were presented in a Reicher (1969) letter-detection paradigm in which the stimuli were presented for 30 ms followed by a pattern mask. After the mask, subjects attempted to report the letters from the display. The results indicated that subjects produced considerably more letters from the nonwords that were assigned a definition compared to the nonwords that were given extra visual processing at encoding. Thus, the meaning of the words appeared to influence letter-level perceptual processes. Moreover, comparisons across experiments indicated that mere exposure to the stimuli was not influencing the "meaning superiority effect."

Of course, there are alternative accounts of this finding. One might simply be that the meaning assignment to the nonwords provided more integration of the letters in encoding and this produced the higher recall. A more tempting account from the present perspective is that meaning-level analyses reinforced the lexical-level representation and this in turn influenced the letter-level representations. That is, the meaning of a stimulus word also influences the perceptibility of the individual letters in addition to its lexical-level representation. As noted later, a simple extension of the McClelland and Rumelhart (1981) framework to include meaning-level representations could easily accommodate this finding.

The effect of meaning on letter recognition is similar to the research by Balota et al. (1989) described earlier. As noted, Balota et al. provided evidence that conceptual-level relationships influenced the speed of accessing the phonemes that are included in the production of a given word. Thus, a higher-level relationship involving the meaning between words appears to influence the access of relatively lower-level codes. In the case of the Whittlesea and Cantwell study, this meaning-level input influenced the speed of accessing the letter-level representations, whereas, in the case of the Balota et al. study, this meaning-level input influenced the speed of accessing the phonological codes used to pronounce the word aloud.

A second study that appears to provide evidence for an impact of meaning on perception has been reported by Forster (1985). Consider the results from his first experiment. Forster presented obsolete words such as *holimonth* in a masked-repetition priming LDT. Forster was using the masked repetition effect as a metric of accessing lexical representations. That is, masked repetition priming presumably reflects facilitation in accessing a lexical representation that is still activated via a recent access. The importance of the mask is that it insures that the priming effects reflect pure repeated access effects, as opposed to episodic influences from their earlier presentation. Forster argued that because the obsolete words used in the experiment were unknown to the subjects, they should not be contained in the subject's lexicon and, therefore, should not exhibit a masked repetition priming effect. This is precisely what Forster found in Phase One of his first experiment. There was no masked-repetition priming effect for the obsolete words. However, after Phase One, subjects were provided information about the nature of the obsolete words, and their corresponding definitions. Forster found in Phase Two that the same obsolete items that earlier produced no evidence for a masked-repetition priming effect now immediately produced a large effect. Moreover, because items were repeated five times for a given subject, and there was no evidence for a change in the size of the priming effect, it appeared that the effect was not dependent upon episodic exposure of the obsolete words during the definition aspect of the experiment. The important point to note here is that the same strings that did not produce a masked-repetition priming effect now produced an effect when these items were given meaning. It would, of course, be interesting to address whether the meaning is actually the crucial factor here or whether simply indicating to subjects that these items deserve a "word" response would be sufficient. Unfortunately, such an experiment has yet to be conducted.

A third set of experiments that should be noted here are experiments that address the impact of semantic variables on isolated lexical decision performance. For example, James (1975), Kroll and Merves (1986), and Schwanenflugel, Harnishfeger, and Stowe (1988) have produced evidence indicating that concrete words produce faster lexical decisions than abstract words. Hence, an apparent semantic dimension, concreteness of the referent of the word, appears to influence a major task that presumably reflects the magic moment in word processing. In addition, Chumbley and Balota (1984) found that associative response latency was a strong predictor of lexical decision performance, and Balota and Chumbley (1984) found instance dominance (as defined by Battig & Montague, 1969) was a strong predictor of lexical decision performance (also see Whaley, 1978). In these latter studies, the influence of lexical variables were presumably partialled out. Finally, Jastrzembski (1981) and Millis and Button (1989) found that the number of meanings available for a word is a strong predictor of lexical decision performance above-and-beyond the impact of word frequency. Thus, these experiments suggest that if one uses lexical decision as a reflection of word recognition performance, meaning variables clearly play a role in word recognition.

## Some Caveats

Before leaving the empirical support for meaning-level influences on word recognition, it is important to note some obvious alternative accounts of the present discussion. First, it is possible that the threshold priming effects might simply reflect intralexical-priming effects. As noted in De Groot (this volume), there is considerable debate concerning whether priming effects occur within the lexical system and/or within the semantic system. Second, as noted, the data presented on deep dyslexia can also be interpreted as indicating a breakdown in the phonological output lexicon. Third, both the Forster (1985) results and the Whittlesea and Cantwell (1987) results could be interpreted as suggesting influences at the lexical level instead of the meaning level. Although one can provide alternative explanations of the available data, the important point to note here is that meaning-level interpretations of these results appear just as viable at the present point in time. Hopefully, this potential interpretation should at least serve as a catalyst for more direct investigations of the impact of meaning-level information on word recognition.

## A POSSIBLE FRAMEWORK

The present discussion has emphasized a number of distinct theoretical and empirical positions. First, it was suggested that the lexical decision and pronunciation tasks are insufficient data sources to localize effects of variables leading up to and including the magic moment. Second, it was noted that one major deficiency in the available models and the interpretation of the available data on word recognition is an emphasis on nonmeaning analyses of words. Thus, the important functional utility of words (i.e., to convey meaning) may be underemphasized in the available models. Third, empirical data were presented that suggest that recognition, at some level, may not always precede meaning analysis, and meaning in some tasks can contribute to what appear to be perceptual operations.

### Two Possible Accounts of the Early Influence of Meaning

There are two obvious theoretical frameworks that one could use to account for a more direct influence of meaning on word recognition. First, as noted earlier, one might consider a slight modification of the highly interactive system proposed by McClelland and Rumelhart (1981). In their framework, there are featural-level representations, letter-level representations, and word-level representations. Activation spreads bidirectionally across levels with inhibitory pathways within a level. For example, when the word *dog* is presented, the letter *d* in *dog* receives some additional activation from the word-level representation *dog*. (This is how the model accounts for the word-superiority effect.) Thus, the higher-level lexical representations contribute to the lower-level letter representations. This is due to the cascadic nature of the processing system. That is, information from one level can influence higher and lower levels in the system without the completion of processing at any of the individual levels (McClelland, 1979). To incorporate meaning-level analyses on performance, one might simply add a meaning-level representation above the lexical-level representation. In addition, one would need to incorporate both bottom-up and top-down pathways from this level of analysis. Such a framework is presented in Figure 2.1.

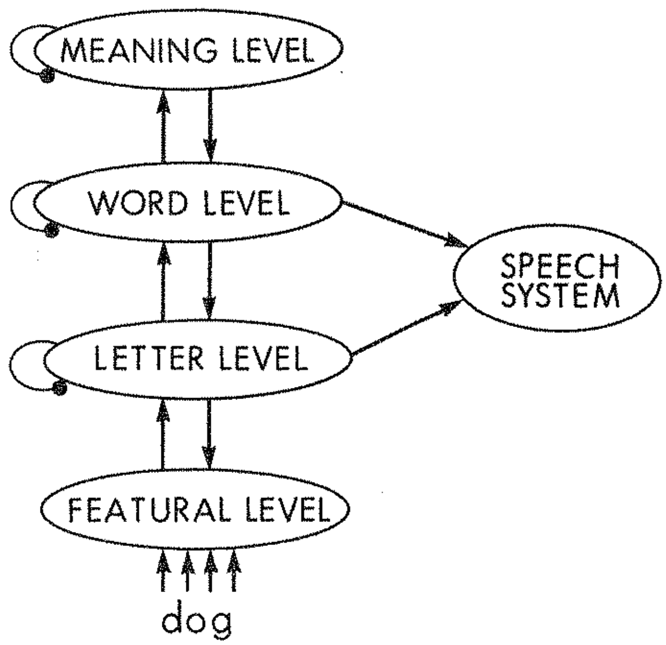


**FIGURE 2.1.** Potential interactive activation framework for word recognition including meaning-level influences.

An alternative framework that is more in the tradition of the flow-diagram models used to describe lexical performance is displayed in Figure 2.2. This framework is very similar to suggestions made by Allport (1977), Marcel and Patterson (1978), Morton and Patterson (1980), and Newcombe and Marshall (1980). The basic notion is that when a visual stimulus is presented, it is coded in multiple ways. One route of coding is a direct picture-level access route to the lexicon. A second route involves graphemic analyses. A third route involves grapheme-to-phoneme conversions. For most high-frequency words, the direct route to the lexicon has the strongest impact on word recognition. The graphemic and phonological routes also play a role, but their impact is relatively diminished for skilled reading. The impact of meaning here again involves the cascadic influence from the lexicon to the semantic system and back to the lexicon. Moreover, as the lexical representations become activated, they also reinforce the graphemic and phonological systems. Thus, the meaning-level analysis helps to tune and stabilize the perception of consistent elements.

The major difference between the two accounts displayed in Figures 2.1 and 2.2 seems to be in the routes to the lexicon. In the interactive activation framework, displayed in Figure 2.1, the notion is that the lexicon is always accessed via featural and orthographic information. The alternative framework, displayed in Figure 2.2, suggests that there are both direct routes to the lexicon and indirect routes to the lexicon via graphemic and phonological information. Thus, these different routes would appear to have a more distinct representation in the latter framework. Moreover, the direct route in Figure 2.2 is only part of the general system for recognizing objects. Thus, the same mechanisms involved in general pattern recognition are viewed as being involved in word processing, even though they might feed into different representations.

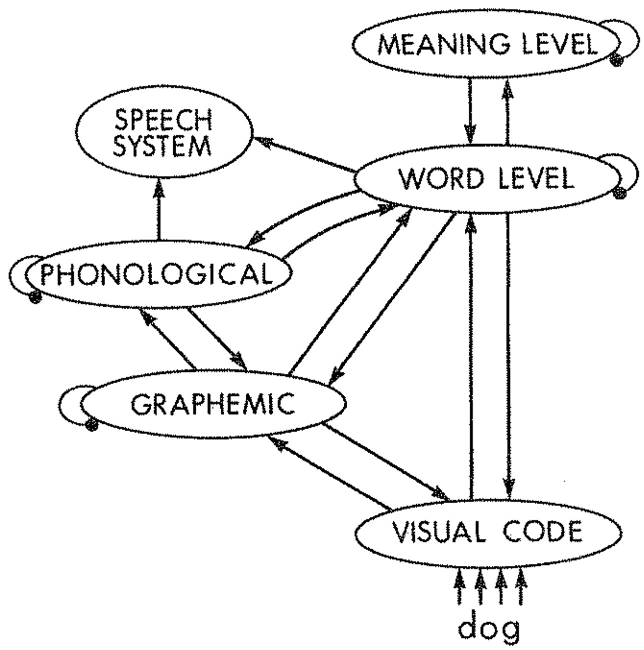


**FIGURE 2.2.** Potential flow-diagram framework for word recognition including meaning-level influences.

Interestingly, there has been some recent evidence for a more direct lexical route. Howard (1987) has reported evidence concerning an acquired dyslexic patient who was at chance at matching a lower-case target letter (e.g., *b*) to an upper-case target in a four-alternative forced-choice procedure (e.g., *K, B, D, L*). Thus, this individual does not appear to have an intact abstract letter code. Interestingly, however, this individual could still read aloud 30 - 40% of the isolated words presented to him. Howard argued that this was possible via the more direct route to the lexical system. Similar arguments have been made based on the phenomena of word-form or spelling dyslexia (Kinsbourne & Warrington, 1962; Warrington & Shallice, 1980) in which subjects can only read by spelling out the words letter by letter. Here, the argument has been that the direct access route to the lexicon is disrupted, but the abstract letter route is intact. Because of the importance of the direct route, these patients read only very slowly and laboriously.

In sum, it should be noted that the theoretical frameworks displayed in Figures 2.1 and 2.2 are not novel. Moreover, the frameworks could be easily modified so that they make isomorphic predictions. It is unclear how one could provide a strong test to distinguish between these two classes of models, although one could distinguish between these two particular instantiations. Currently, one might prefer the framework that is in the vein of that displayed in Figure 2.2 because of the distinction between different access routes. It would seem that the masked-priming effects and the evidence from deep dyslexia suggest that one can block one of the access routes while leaving other access routes intact.

## Meaning Representation: An Alternative Approach

A major issue that has not been discussed is what meaning representation might involve. This is a very difficult issue that has produced considerable psychological and philosophical debate. For example, one consistent problem that has occurred in the literature on word meaning is whether it should be attributed to a single prototype representation or whether it should be attributed to a list of semantic features. In both approaches, the meaning of a stimulus word is viewed as representing some core set of information.

An interesting alternative approach to meaning representation follows from suggestions made by Hintzman (1986, also see Medin & Schaffer, 1978; Schwanenflugel & Shoben, 1983). Hintzman has developed an instance based model of prototype development that does a very good job of accounting for some of the core data supporting prototype representations. For example, consider the classic study by Posner and Keele (1968). These authors presented subjects a set of instances that were formed by pseudorandom permutations of a single random dot prototype. The actual prototype that the instances were based upon was not directly presented to the subjects. The results indicated that, after some delay, subjects were more confident in recognizing the prototype that was not directly presented than the instances that were directly presented. Posner and Keele argued that this pattern supports the notion that subjects abstract the prototype from the individual instances and store the abstracted prototype directly in memory. In contrast to this interpretation, Hintzman argued that each of the episodic experiences with the instances produces a unique episodic memory trace that consists of a list of primitive features. The higher recognition memory for the prototype reflects the fact that the test stimulus in some sense partially activates all of the episodic traces. In fact, the partial overlap with many of these traces produces a stronger match (echo) than the stronger overlap with a single instance-based trace. Thus, the culmination of many different, but related, episodic memory traces produces the higher recognition confidence for a stimulus (i.e., the prototype) that was never directly presented.

The relevance of this approach to meaning representation is quite straightforward. Meaning of a given word is not simply represented as a list of isolable semantic features or a prototype but rather should be conceived as a cumulation of individual episodic experiences with that word. Each of the experiences (i.e., the word and its embedded context) contributes to the evolving meaning that we attribute to a given word.

One advantage of this approach is that it very nicely accommodates the large degree of context dependency in word meaning. This dependency follows from this framework because the precise trace that is retrieved by the stimulus will depend on the context in which the word is embedded. Different contexts will yield different combinations of episodic traces that are activated.

Obviously, this brief discussion poses more questions than it provides answers. For example, it is crucial to specify what are the primitive features of word meaning that might contribute to the episodic memory traces. Moreover, it is crucial to specify how context contributes to the retrieval of episodic representations. The contribution of this discussion is simply to consider meaning of words as the combinatorial action of individually encoded episodic traces as opposed to distinct semantic representations. This approach may lead to a more fruitful functional account of word meaning.

## SUMMARY

The goal of the present discussion is simply to bring meaning back into word recognition. It has been argued that there is no unequivocal evidence that suggests that one can empirically tap the word-recognition stage without meaning analysis. Moreover, even if one could develop a task that is sensitive to pure meaning-free lexical access, one would then have to be concerned about the relevance of performance in that task for linguistic processing. At this level, it is necessary to remind ourselves that the functional value of words is to convey meaning, not to convey orthography, phonology, or lexicality.

## ACKNOWLEDGEMENTS

The author expresses his gratitude to the Netherlands Institute for Advanced Study for their generous support while the present chapter was written. Thanks are also extended to Simon Garrod, Ino Flores d'Arcais, Odmar Neumann, Keith Rayner, and Paula Schwanenflugel for their helpful comments on an earlier version of this chapter.

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