

Final Draft

Lexical access, cognitive psychology of

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In order to produce and understand language, whether it be spoken or written, an individual must have available some form of cognitive representation of the words of their language. This pool of mentally stored information is called *lexical memory* or the *mental lexicon*, while *lexical access* refers to the retrieval of such information. Initial research into the mechanisms of lexical access focused primarily on visual word recognition and, indeed, the term "lexical access" was originally coined in relation to this domain (Forster & Chambers, 1973). However, in more recent years, the term is more commonly applied to language production rather than to language recognition. The reason for this change in the pattern of its usage arises from the fact that it is not a theoretically neutral term and is no longer concordant with the currently dominant theoretical approaches to visual word recognition (see also *Word Recognition, Cognitive Psychology of*). This will be detailed below.

1. Use of the Term "Lexical Access"

1.2 Accessing a Lexical Entry

The earliest attempts to explain how information is retrieved from lexical memory equated the stored representation with a dictionary entry. Thus, the task of word recognition was seen to involve access to a discrete *lexical entry*, either via a search procedure (e.g., Forster & Chambers, 1973) or by activating it to some threshold on the basis of features extracted from the stimulus (e.g., Morton, 1969). Thus, for a visually presented word, a match is made between a coded sensory representation of the stimulus and the representation of the form of the word as stored in lexical

memory, that is, there is a *sensory-to-lexical* match. This is the process that has been labelled "lexical access". Once the match is made, the functional characteristics of the word become available (i.e., its meaning and its grammatical characteristics) because these are associated with the lexical entry, and any processing that makes use of this information is therefore said to be *post-access* or *post-lexical*.

In contrast, *pre-access* or *pre-lexical* processes refer to any processing that takes place prior to the sensory-to-lexical match being achieved; for example, the conversion of specific font information into some abstract letter code. The topic of pre-lexical processing is notably germane to the issue of *phonological recoding* (see later).

1.2 Connectionist Models of Lexical Processing

In the 1980s, the advent of connectionist modeling of word recognition processes led to a conceptualization whereby lexical information does not reside in a discretely defined entry.

In *localist* connectionist models (e.g., the Interactive-Activation account of McClelland and Rumelhart, 1981), although there may be discrete units of activation that represent the words of the language, there are also units representing subword (i.e., *sublexical*) entities (e.g., letters). Sublexical activation is as integral to the recognition of the word as is lexical activation because there is an interaction between the sublexical and lexical levels in the determination of the output. In such a model, the process of matching the stimulus with a memory representation of the word involves not only the accessing of lexical information, but also sublexical information. Indeed, the whole word need not be represented at all, because its meaning could be

activated solely via sublexical units (see Taft, 1991). So it is somewhat misleading, within this framework, to use the term "lexical access" to refer to the actual matching process because it may not be based on lexical information, at least not exclusively. However, the term could be appropriately used to refer to the outcome of the matching process, namely, the point at which information about the whole word is activated to some criterion of acceptability and is therefore "accessed".

In *distributed* connectionist models (e.g., the Parallel Distributed Processing model of Seidenberg and McClelland, 1989), the presented word activates a set of input units that produces a pattern of activation in a set of output units (via an intermediate set of hidden units) with no explicit lexical representation. (See *Distributed Cognition*). This again obscures the idea of lexical access as a process of finding a sensory-to-lexical match. Nonetheless, at some point in processing, the system must settle on a particular output as being the most relevant to the input and, because this means that information about the word has become available for response, it could be argued that this is when "lexical access" has occurred.

So, within connectionist accounts of word recognition, "lexical access" refers most appropriately to the final outcome of processing rather than to the processing itself. The use of the term has therefore waned, because the central interest of cognitive investigations into word recognition is the nature of the actual processes involved in identifying a word and not the mere fact that the word is recognized. For this reason, the more general term "*lexical processing*" tends to be preferred.

1.3 The Scope of the Term "Lexical"

Even when the term "processing" replaces the term "access", there still remains an

issue of the scope of the term "lexical", which is simply the adjective for the noun "word". A word has a form (both phonological and orthographic), and also a function (both semantic and syntactic). Is the processing of the form of a word sufficient to say that lexical access has occurred, or is access to the meaning and syntactic class of the word required as well? This is rarely, if ever, specified in the literature. Certainly when the semantic (or syntactic) information about a word participates in processing at the sentence level, this must be occurring "post-access"; but it is still debateable whether the actual extraction of this information should be also seen as a "post-access" process or part of lexical access itself.

1.4 Language Production

When language is generated, meaning is being translated into form. The term "lexical access" is still frequently used in relation to language production (where most of the research focuses on speech rather than writing). The continued use of the term perhaps reflects the fact that the interface between the meaning and form of a word is largely arbitrary and, therefore, the processing of the form-level representation (called the *lexeme*) does not involve the gradual increment of activation based on sublexical information. However, theorists in speech production propose that a lexical item consists not only of the lexeme, but also of a functionally defined representation, the *lemma*, that is selected on the basis of the desired meaning (see *Speech Production, Psychology of*). The term "lexical access" is used to refer to retrieval of the lemma as well as the lexeme, with the main theoretical issue being the relationship between the two (see e.g., Dell & O'Seaghdha, 1992; Levelt, 1992).

1.5 A Lemma in Word Recognition?

If the notion of an abstract lexical unit (i.e., the lemma) mediating between meaning and form is accepted for word production (though see Caramazza, 1997), then the same should hold for word comprehension. The involvement of a such a unit in the word recognition system has only recently been considered (see e.g., Baayen, Dijkstra, & Schreuder, 1997). A lemma-level would represent units that link form and function and, as such, could be considered the core lexical representations, that is, units that allow access to all the information about a word. In terms of word recognition, then, lexical access occurs when a lemma is sufficiently activated via the form-level representations that are appropriate to the incoming sensory information. Thus, as in word production, lexical processing in word comprehension (be it visual or auditory) can be defined in terms of access to two types of representation, one defined in terms of form and one in terms of function.

2. Issues in Lexical Processing

For issues related to lexical processing in word production, see *Speech Production, Psychology of*. The following will concentrate solely on issues concerning lexical processing in word recognition. The focus will be on the processing of visually presented words, given the dominance of this domain as a research area. However, issues specific to lexical processing in speech recognition will be also be considered.

2.1 Modality of Access

When a word is visually presented, it is obviously a logical possibility that the form-based representation that is accessed is an orthographically coded one (i.e., one that is

compatible with the visual characterization of the word). However, for a long time it has been suggested that when words are to be read, they are recoded in terms of their sound, that is, they are recoded phonologically (see Taft, 1991, Chapt.4), even though they do not need to be overtly pronounced. After all, recognizing spoken language is an ecologically more fundamental skill than recognizing written language. The idea is that the form-based lexical match is made in the phonological modality, and this means that the visually presented item must be recoded into its sound prior to accessing any lexical information, i.e., pre-lexically. This is achievable via a set of rules that convert letters (i.e., graphemic information) into sounds (i.e., phonemic information).

However, there are languages, like English, for which such *grapheme-to-phoneme conversion* (GPC) rules will not always be successful (e.g., there would be no way of knowing that the EA of GREAT and the EA of TREAT are pronounced differently). Therefore, the phonological representation of an irregular word (like GREAT) must be generated on the basis of information about the whole word. So, there must be a means of accessing such information other than via a phonological recoding of the visual stimulus. That is, if phonological information about a word could only be accessed via GPC rules, GREAT would always be recoded into the same pronunciation as GREET and therefore confused with that word. Clearly, the form-level access of an irregular word like GREAT must be achieved on the basis of orthographic information, and the associated phonology of the word can then be made available post-lexically.

Saying this, however, assumes that "lexical access" refers only to form-based

access and not to access of meaning or of a lemma. "Post-lexical", in this context, would not refer to processing that occurs after the meaning is accessed, that is, it is unlikely that the phonology of a visually presented word would only become available after its meaning does. Indeed, to the contrary, it has been proposed that the primary route to meaning is *via* the phonological representation (see Frost, 1998). There is a large body of research that suggests that the pronunciation of a word is activated in the course of reading silently for meaning. However, it still remains controversial whether this entails phonological mediation between orthographic processing of the stimulus and access to its meaning (Frost, 1998), or whether meaning is primarily accessed via orthographic information in silent reading and that automatic activation of phonology occurs independently, perhaps for the purposes of holding the material in working memory (see Taft & van Graan, 1998).

2.2 Use of Internal Word Structure.

Words are more than just a linear concatenation of letters (or phonemes). There is an internal structure whereby some letters go together more closely than others. In the word PICNICKING, for example, the *morphological* structure is PICNIC (stem) and ING (affix), while the stem itself has the *syllabic* structure PIC + NIC. In turn, each syllable has the same vowel plus consonant unit (i.e., IC), called the *rime* or *body*, with a different consonantal *onset* (P and N). There is a growing body of research that suggests that analysis of this internal structure takes place during the course of lexical processing. Studies in a wide range of languages indicate the importance of morphological analysis (see e.g., Feldman, 1995), while the existence and nature of syllabic processing seems to be determined by the characteristics of the language

involved (e.g., Cutler et al, 1986). Onset/rime analysis has also been clearly demonstrated, but so far only in English (e.g., Treiman et al, 1995).

In theoretical terms, the importance of such units of analysis means either that they are explicitly represented as sub-lexical entities within the processing system (see e.g., Taft, 1991) or that they implicitly emerge as a reflection of the statistical characteristics of the relationship that exists between orthography, phonology and meaning (e.g., Seidenberg & McClelland, 1989).

2.3 Lexical Processing in Context.

When a word is presented in isolation, the only basis for recognition are the sensory features extracted from the stimulus, i.e., *bottom-up* information. When presented in a sentence context, however, there is the additional possibility of anticipating what the word is on the basis of semantic or syntactic expectations (i.e., *top-down* information), thus reducing the importance of bottom-up processing. So, is it the case that lexical processing qualitatively changes when the word is placed within a sentence context?

Although the recognition of a word (e.g., MIRROR) might be facilitated by the presence of a highly predictive context, like SHE LOOKED AT HERSELF IN THE, research suggests that there is no advantage in having a compatible, but not so predictive context, like SHE LOOKED FOR A (see Taft, 1991, Chapt.3). The most robust effect of context actually appears to be its inhibitory impact on word recognition when the word is incompatible with the context. For example, the time taken to recognize MIRROR is delayed by the immediately prior presentation of SHE ATE THE DELICIOUS. It has therefore been concluded that context has its major influence at a post-access stage and that its main role is to suppress inappropriately

accessed candidates (e.g., Forster, 1981).

If a word is being accessed in the same way whether it fits the context or not, the two meanings of an ambiguous word (e.g., PORT) should be accessed in the same way regardless of any contextual bias (e.g., AFTER DINNER HE DRANK A GLASS OF PORT versus THE SHIP CAME INTO PORT). The contextual bias should only come into play by suppressing the inappropriate meaning at a post-access stage, rather than by preventing the inappropriate meaning being accessed at all. In fact, there have been a number of studies supporting this position, though there may be some impact of the appropriateness of the context at an early stage as well (see e.g., Simpson, 1984).

Note that an ambiguous word has a single representation at the form level, but two representations at the lemma or meaning level. Therefore, if context is said to have its selective effect post-lexically rather than pre-lexically, then "lexical access" must be used here to refer to the function-based level of access (because there is nothing at the form-based level to select). So, we see that there is potential for confusion in the understanding of lexical access because, in relation to the issue of phonological mediation in silent reading, the terms "pre-lexical" and "post-lexical" were used to refer to form-based, but not function-based access. When using such terminology, then, one needs to be aware of its scope of reference within the context within which it is being used.

2.4 Lexical Processing in Speech Comprehension.

There are aspects of lexical processing that are specific to the recognition of spoken words as opposed to written words (see *Speech Perception*). First, while most

alphabetically written scripts physically separate each word within a sentence, the speech signal does not provide any reliable indication of word boundaries. Therefore, in the recognition of spoken words there is no guarantee that the sensory information being processed corresponds to a whole word: It may even be that what one initially processes as the beginning of a word is actually the end of the previous word. Unlike in reading, though, the physical signal contains prosodic features (notably, patterns of stress) and these have been shown to be important cues in determining word boundaries (e.g., Norris et al, 1995).

A second feature of the speech signal is that its presentation to the sensory system is not under the control of the recipient: The acoustic features of the speech signal are exposed to the auditory system fleetingly and in a fixed temporal order. Therefore, these features must either be processed continuously on-line or accumulated within a memory buffer for later processing. When reading a text, on the other hand, one has the freedom to move one's eyes to wherever one chooses and it is possible to take in information from anywhere within a word. Furthermore, while processing a word in the foveal region of the eye, it is possible to begin parafoveal processing of the upcoming information, which can potentially influence subsequent foveal processing of that information (see *Eye Movements in Reading*). So, in speech comprehension, the temporal characteristics of the signal are likely to have a major impact on lexical processing and this is indeed a feature of models of spoken word recognition (see e.g., Marslen-Wilson, 1989).

3. Measuring Lexical Processes

Again, the primary focus here will be on visual word recognition. For experimental

tasks in the areas of language production and speech recognition, see *Speech Production, Psychology of* and *Speech Perception* respectively.

3.1 Experimental Tasks

In order to gauge the processes involved in accessing a word in lexical memory, a task is required that cannot be performed on the basis of pre-lexically derived information. One commonly used task is where the presented word must be overtly named and the latency to begin the pronunciation is measured. While this *naming task* provides a good measure of the processes involved in generating sound from print, it is not necessarily a good measure of lexical processing because it is possible at least to begin pronouncing many words on the basis of units smaller than the word (i.e., the initial letters).

The task that is the most widely used is one that makes use of the obvious fact that lexical memory only contains words that have been encountered before. The item FLINK could potentially be a word in English, but is actually a *nonword* or *pseudoword*. Unlike an unstructured letter-string like LKNFI, the only way to know that FLINK is a nonword is to establish that it does not exist in the lexicon. Therefore, if asked to classify items as "word" or "nonword", the only way to do so is to consult lexical memory. So the time taken to classify a word as a word in this *lexical decision task* is taken as a measure of the ease of lexical access. The sort of experiments that are undertaken using this task tend to compare two sets of words that differ on one characteristic while being as similar as possible on all other potentially important characteristics. If the two sets differ in their lexical decision response times, it is concluded that the manipulated characteristic plays a role in lexical processing. For

example, two sets of words of the same length will produce different lexical decision times if they differ on their frequency of occurrence in the language and, therefore, any account of lexical processing must consider the role of word frequency (see Taft, 1991, for other examples).

The characteristic that is manipulated need not be a feature of the word itself, but instead a feature of the presentation conditions. The most common presentation manipulation is to precede the target item with another item that is related in some way to it. This other item is called the *prime*. If the prime has an impact on responses to the target, it indicates that the characteristic on which they are related plays a role in lexical processing. For example, faster lexical decision times to DOG when preceded by CAT (compared to when preceded by CAP), suggests that lexical access involves a semantic level of analysis. See *Priming, Cognitive Psychology of*.

3.2 *The Cognitive Neuropsychological Approach*

Conclusions have also been drawn about lexical processing by studying acquired dyslexics (see *Dyslexia, Cognitive Psychology of*). These are people who were able to read normally before a trauma to the brain (e.g., through accident or stroke) resulted in a dysfunction in processing. Research into the reading behavior of such dyslexics has been influential in the development of accounts of lexical processing. If it is found that an individual has one area of functioning disrupted, but another intact, it suggests that those two aspects of processing are independent of one another. For example, some dyslexics (*surface dyslexics*) can read aloud nonwords and regular words, but not irregular words, while others (*phonological dyslexics*) only have a problem with nonwords. Such a pattern of dysfunction is taken to support the existence of two

routes from print-to-sound (see Coltheart et al, 1993), namely, a lexical route where the phonology associated with the whole word is available (disrupted for surface dyslexics) and a rule-based GPC route (disrupted for phonological dyslexics).

3.3 Direct Measures of Processing

Lexical access can also be examined by looking directly at the organs involved in the process, namely, the eyes and the brain. By examining eye movements, an analysis can be made of the timing and placement of fixations during the course of normal reading. Manipulations of lexical information both in the fovea and parafovea have provided a rich source of data regarding the processing of words. See *Eye Movements in Reading*.

Direct observations of the activity in the brain when words are presented (e.g., using ERP, fMRI and PET techniques) is also beginning to provide fertile ground for an understanding of lexical processing, though the contribution of this research is likely to be more in determining the physical locus of aspects of processing than in providing a fine-grained analysis of this processing. See ????

NB Other potentially related topics not mentioned already: *Reading Non-Alphabetic Scripts; Reading Skills; Literacy, Cognitive Psychology of; Writing Process, Psychology of.*

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