
**Further Reading**


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**Lexical Ambiguity Resolution**

*Intermediate article*

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Most words have several meanings, yet readers and listeners are able to determine a writer’s or speaker’s intent from the word’s context. Research on the resolution of lexical ambiguity has developed not only theories on how comprehenders settle on a single meaning, but also experimental paradigms for examining this process.

**INTRODUCTION**

A small number of words in English are lexically ambiguous in that one spelling and/or one pronunciation is associated with two unrelated meanings – for example, ‘spoke’. This small set of words has been the topic of hundreds of journal articles and book chapters since 1970. One reason for this great research interest is that almost all other words are ‘polysemous’ – they have multiple but related senses. Consider ‘clear’ as in ‘passes light’ versus ‘easy to understand’; ‘running’ in ‘running a marathon’ versus ‘running for election’; and ‘paper’ in ‘wrapping paper’ (substance) versus ‘liberal paper’ (institution). Britton (1978) reported that 44 percent of a random sample of English words had more than one dictionary definition. The more commonly a word is used, and the longer it has been part of the language, the more meanings it possesses (Zipf, 1945; Lee, 1990). Linguists and psycholinguists have wrestled with the proper treatment of the one-to-many mapping between word forms and word senses (Klein and Murphy, 2001), and many consider ambiguity to be the extreme end of a continuum of polysemy. Studies of ambiguity resolution thus concern a fundamental aspect of comprehension – how readers and listeners identify the contextually appropriate senses of words.
Most lexical ambiguity research has been conducted in English, but ambiguity and polysemy also occur in the world’s other languages. For example, one-to-many mappings between pronunciations and meanings are prevalent in spoken Chinese (Li, 1998), so that by one count the syllable ‘yi’ (with dipping tone) has 90 different meanings in Mandarin (Yip, 2001). (See Lexicon; Lexical Semantics; Word Meaning, Psychology of)

MODELS OF AMBIGUITY RESOLUTION

In everyday language use, the meaning of words is clarified by their context. Laboratory studies have focused on how comprehenders use context to arrive at the relevant word sense, and have suggested three different models. The exhaustive access model proposes that comprehenders first activate all possible senses of a word, then use context to select one meaning. The ordered access model suggests that comprehenders initially activate the most common sense of a word, and proceed to less common senses only when the initial meaning does not fit the context. The selective access model suggests that appropriate prior context can direct comprehenders to the relevant meaning of a word immediately. Hybrid models are also possible, for instance that access is selective when the context is strong, but that the most frequent meaning is initially accessed with less constraining context. The following text provides a snapshot of different and often conflicting empirical findings. For a discussion of computational models of lexical ambiguity resolution, the reader is directed to articles by Kawamoto (1993) and Dixon and Twilley (1999).

THE CONTEXT–AMBIGUITY–PROBE PARADIGM

A commonly used paradigm for investigating ambiguity resolution consists of three stimuli: a semantic context biasing one sense of the ambiguity, the ambiguous word, and a probe word. The context may be a single word (‘iron bar’ versus ‘gay bar’), a sentence frame providing semantic context (‘She covered the floor of the stable with clean straw’) or a sentence frame providing syntactic context alone (‘He needed to change’ versus ‘He needed some change’). Probe words are related to the contextually relevant sense of the ambiguity, to the irrelevant sense, or to neither (in the last example, ‘clothes’, ‘coins’ or ‘water’). Responses to the probe word are the critical measure, in particular whether responses to irrelevant probes more closely resemble the relevant or the unrelated condition. Important factors include:

- the amount of time between the ambiguity and the probe
- the nature and strength of the context
- the dependent measure, or how the processing of the probe word is evaluated
- whether the sentence biases the more common (dominant) or less common (subordinate) meaning of the ambiguity (Simpson, 1994).

Two reaction time (RT) tasks are sensitive to semantic relationships: deciding whether a letter string is a word or a nonword (lexical decision time), and reading a written word aloud (nam ing latency). Table 1 shows a typical pattern of results in the context–ambiguity–probe (CAP) paradigm: when a short time elapses between the ambiguity and probe (around 200 ms), responses to the contextually irrelevant probes are faster than to unrelated words. When a slightly longer time elapses (around 700 ms), responses to the irrelevant probes are equivalent to those elicited by unrelated words (Swinnen, 1979). These results have been taken as support for the exhaustive access model. The interpretation is that, when presented quickly enough, contextually irrelevant probes are processed as related because both meanings of the ambiguity are still active. A short time later, the second stage of semantic processing selects the contextually relevant sense of the ambiguity, and the contextually

<table>
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<td>200 ms SOA</td>
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<td>591 (73)</td>
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Values are in ms, standard deviation in parentheses. SOA, stimulus onset asynchrony, the time between the onset of the ambiguous word and the onset of the probe word.
irrelevant probe is now processed as unrelated. (See Language Comprehension, Methodologies for Studying; Lexical Access; Word Recognition)

Nature and Strength of the Context in the CAP Paradigm

The finding of faster RTs for contextually irrelevant probe words than for unrelated probe words has been replicated many times and serves as the central support for the exhaustive access model. However, two other experimental findings are problematic for this model. The first is that the majority of experiments showing faster RTs in the contextually irrelevant condition compared with the unrelated condition also show that RTs in the contextually irrelevant condition are slower than those in the contextually relevant condition. A gradient of RTs across conditions is incompatible with all three of the major models in their purest forms. One possibility is that one of the major models is true, and that the pattern of contextually relevant < contextually irrelevant < unrelated RTs is due to imperfect stimulus construction. For instance, a proponent of the exhaustive access model might suggest that contextually relevant probes receive additional contextual support directly from the sentence context, as well as from the ambiguity itself, and that the former contribution is of no interest. A proponent of the selective access model might suggest that some portion of the contexts used in a given experiment were, in fact, too weak to count as good contexts for the desired meaning of the ambiguity.

The second experimental finding that precludes accepting the pure version of the exhaustive access model is that some studies have found equivalent RTs for contextually irrelevant and relevant words – results supportive of the selective access model (Tabossi and Zardon, 1993; Simpson, 1994). Many arguments in this research area revolve around defining both the nature and the strength of context which can (sometimes) lead to such results. For instance, Seidenberg et al. (1982) suggested a three-way distinction between (1) syntactic context (‘a rose’ and ‘he rose’), (2) single-word associative context (as in ‘ship-deck’ and ‘card-deck’), and (3) more global semantic context which is neither syntactic nor associative, but created by the overall meaning of a sentence. In this view, contexts of type 2 can indeed yield selective access because they work via direct word-to-word links within the mental lexicon, but contexts of types 1 and 3 are ineffective in blocking exhaustive access. A different view is that it is unnecessary to postulate different forms of context and that overall strength of context is the critical factor: strongly predictive contexts yield selective access, whereas weakly predictive contexts (such as ‘a’ or ‘to’) are much the same as no context at all (Paul et al., 1992).

The CAP Paradigm and Retroactive Context

Another important issue concerns the logic of the CAP paradigm itself. The standard interpretation of the paradigm is that reaction times to the probe reveal how the ambiguous word was initially interpreted, and that the probe itself has no additional impact. This interpretation assumes that the processing of sequential words is both serial and linear, so that each word can benefit only from what was presented earlier. However, several experiments with unambiguous words have shown that reaction times can be speeded, and error rates reduced, by the presentation of a related word shortly after the target word (Kiger and Glass, 1983; Dark, 1988; Van Petten and Kutas, 1991; Logan and Shulkind, 2000). These retroactive semantic context effects (sometimes called ‘backward priming’) are best understood in terms of temporal overlap in the processing of two words: if a second item is presented while the first is still being processed, both will benefit from their semantic relationship, much as a simultaneous pair of words are processed more rapidly if related than unrelated. A retroactive-context interpretation of the CAP paradigm suggests that access to a contextually irrelevant meaning is not a spontaneous response to reading an ambiguity, but is instead caused by presentation of the contextually irrelevant probe itself. Although retroactive context effects can clearly occur, the impact of this phenomenon in the CAP paradigm has been contentious (Burgess et al., 1989).

Event-related Brain Potential Measures in the CAP Paradigm

An undisputed finding of the CAP paradigm is that the results are sensitive to small differences in the timing of stimulus presentation, so that one appeal of the paradigm is the possibility of tracking the time course of language processing. A dependent measure that is particularly well suited to examining time course is the event-related potential (ERP), a measure of brain electrical activity that can be recorded as participants read or listen for comprehension. The ERP provides a continuous record of brain activity, so that one can describe the temporal onset and offset of experimental effects with some
precision. One component of the ERP is sensitive to semantic context. The N400 (a negative voltage peaking 400 ms after stimulus onset) is elicited by all words, but is smaller in amplitude when a word fits with an established semantic context than when it does not (Van Petten and Kutas, 1994). (See Event-related Potentials and Mental Chronometry)

When a long period between the onset of one stimulus and the next (stimulus onset asynchrony, SOA) is used in the CAP paradigm, both contextually irrelevant and unrelated probe words elicit larger N400s than do contextually related probes (Figure 1a). These long SOA results are a perfect match with the typical pattern of reaction times. With a short SOA, the exhaustive access model predicts a large N400 only for unrelated probes, and equally small N400s for contextually relevant and irrelevant probes. The results in Figure 1b are somewhat different from this prediction. The semantic relationship between ambiguity and probe word influences the ERP beginning at 300 ms after the onset of the probe word. During the initial phase of the context effect, from 300 ms to 500 ms, the ERP to contextually irrelevant probes is similar to the response to completely unrelated words, indicating early access to only the contextually relevant meaning. Only some time later, from 500 ms to 1100 ms, does the contextually irrelevant response grow to resemble the contextually relevant response. This pattern of results is consistent with selective access, combined with a retroactive context effect. The contextually relevant sense of the ambiguity has a head start in influencing probe word processing, but temporal overlap in the processing of the contextually irrelevant sense and its related probe word is visible later.

**EYE MOVEMENT MEASURES OF LEXICAL AMBIGUITY RESOLUTION**

Gaze durations during reading have also been applied to the problem of ambiguity resolution. Readers generally spend longer fixating words that are contextually unpredictable or low in frequency of use. Gaze duration measures thus offer a naturalistic way of examining a reader’s processing.

![Figure 1](image-url). Grand average event-related brain potentials (ERPs) to ambiguous and unambiguous sentence terminal words and subsequent probe words which were unrelated (dashed line), contextually irrelevant (dotted line) or contextually relevant (solid line). Onset of the sentence terminal words is indicated by an arrow; onset of the probe words is at 0 ms. The ERPs were recorded at a midline central scalp site. Stimulus onset asynchrony (SOA) is 700 ms in (a), 200 ms in (b). Data from Van Petten and Kutas (1987); see also Van Petten (1995) for replication.
difficulty, without the need for an extra reaction time task. Because they do not include probe words, these measures thus avoid the possibility of retroactive semantic context effects.

In the absence of prior semantic context, gazes are longer on ambiguous words with two equally strong meanings (balanced homographs) than on unambiguous words, or on homographs with one dominant meaning. If subsequent portions of a sentence favor the subordinate meaning of an unbalanced homograph, readers spend a particularly long time on disambiguating regions. These findings suggest that readers favor the more common sense of an ambiguity on first reading, and must do some extra work if the two meanings are in close competition, or if their initial choice of meaning turns out to be incorrect.

When prior context biases one meaning, gaze durations for balanced homographs are like unambiguous words, indicating that readers no longer suffer a conflict between two equally likely interpretations (an apparent case of selective access). However, when the prior context biases the subordinate sense of an unbalanced homograph, gaze durations are longer on the homograph than on unambiguous words (Pacht and Rayner, 1993). The latter finding suggests that readers may access the dominant meaning despite the context, supporting the ordered access model. However, others have argued that this result depends on relatively weak contexts, and that strong contexts can produce selective access for even subordinate meanings (Kellas and Vu, 1999). Overall, the gaze duration research has lent little support to the exhaustive access model, but has instead indicated that meaning frequency and strength of semantic context are critical factors in determining which (and how many) meanings of ambiguous words are considered by readers.

CONCLUSION

Disagreements in the domain of lexical ambiguity resolution reflect our imperfect understanding of the sequence of events that yields the comprehension of any word. Future language research that sheds light on the nature of semantic relationships (thus allowing a better quantification of ‘context’), and a detailed understanding of the time course of processing from sensory analysis to semantic integration are also likely to clarify how readers and listeners know when ‘spoke’ means ‘part of a wheel’ and when it means ‘talked’. (See Language Comprehension; Psycholinguistics)

References


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Lexical Development

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Lexical development refers to children’s acquisition of meaningful and grammatical elements of the lexicon.

INTRODUCTION

What comes first? Many people think that words are children’s first linguistic elements. This may be because words are the first meaningful units that we recognize in children’s observable behavior. With the exception of scientists who study this topic, people rarely consider infants’ production of well-formed but meaningless syllables like ‘bababa’ as evidence of language knowledge. However, words are not first in any scientifically interesting sense. Children develop multiple aspects of linguistic knowledge simultaneously, and they do so well before producing their first words. (See Phonology and Phonetics, Acquisition of)

One theme in this encyclopedia is information; another is information processing. The study of lexical development relates to both. First, lexical development refers to children’s mastery of a kind of information. However, the evidence for such mastery is affected by information processing. This distinction between information and the processing of information is comparable to the distinction between competence and performance. Developmentalists face subjects who are clearly gaining both target competence (i.e. representation of information) and proficient performance (i.e. processing of that information). Limitations in

Further Reading


