Meaning Dominance and Context in the Processing of Lexical Ambiguities

By

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ABSTRACT

Homographs can be considered local semantic uncertainties in utterances. As such, a study of how their meanings are resolved can be used to infer the dynamics of retrieval from memory. One view is that resolution always begins with an exhaustive retrieval of the entire set of meanings, followed by a selection of one, either on the basis of the context, or the amount of experience with a meaning (meaning dominance). In support of this two-stage view, two experiments demonstrated that a homographic primer speeds responses to both subordinate and dominant associates if its presentation time is short, but speeds responses to only a dominant associate if its presentation time is long. Two further experiments also found evidence for exhaustive retrieval by showing that a subordinate associate will selectively interfere with pronunciation of a homograph if it is presented in close temporal proximity. However, whether exhaustive retrieval is the rule for the processing of homographs depends on how immune the initial retrieval is to manipulations of context. Four subsequent experiments demonstrated that if subjects study the actual homographs before employing them as primers, there are conditions in which the critical effects that support exhaustive retrieval are eliminated. Furthermore, across a number of experiments, measures of episodic memory showed small but replicable selective effects in conditions presumed to reflect only non-selective operations.

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Chapter 1

LEXICAL AMBIGUITY AND ITS RESOLUTION

> [W]ords of ambiguous meaning are chiefly useful to the sophist to mislead his hearers.
>
> Aristotle (Quoted in Ullman, 1972)

> [A] striking feature of natural language is that, grammatical function words apart, the more frequently used a word is, the more likely it is to be ambiguous.
>
> Johnson-Laird (1983)

An intriguing feature of the semantics of natural language is that the symbols and grammars used to express concepts are, if taken out of linguistic context, often compatible with different interpretations. Of interest to psychologists is the fact that this does not normally block effective communication, nor are speakers or listeners typically aware of semantic ambiguity. A reading of the following sentence (Johnson-Laird, 1983, p. 233) serves to illustrate both the ubiquity and ease-of-resolution of one form of semantic ambiguity, single-word or lexical ambiguity.

> The plane banked just before landing, but then the pilot lost control. The strip on the field runs for only the barest of yards, and the plane just twisted out of the turn before shooting into the ground.

Despite the fact that virtually all of the content words in this sentence have a number of possible interpretations, fluently understanding its meaning is not compromised. From a psychological perspective, if actual decisions are made by the normal language-user about what interpretation to assign to an utterance, these decisions must be made by mental mechanisms in a surprisingly efficient manner, without awareness of their occurrence. A reasonable intuition is that ambiguity is not normally a problem precisely because mental mechanisms rapidly and effortlessly integrate various sources of contextual information to effect a non-ambiguous outcome, and it is only this outcome of which we are aware. Therefore, the challenge for a psychological model of lexical disambiguation is to account for both the rapid, efficient processing characteristic of fluent language use, and the flexible, contextually-sensitive processing necessary for successful adaptation to a variable linguistic environment.

The experiments reported in the thesis are concerned with the psychological processes that mediate the normally effortless resolution of semantic ambiguity. Interest will focus on the resolution of lexical ambiguity, the ambiguity of single words. Although the concern is thus restricted, the issues raised by lexical ambiguity are surprisingly general, having ramifications for psychological theories of semantic memory and word recognition (Simpson, 1984). The goal of chapter 1 is to define the theoretically interesting aspects of the problem, beginning with some linguistic aspects of lexical ambiguity, and followed by psychological considerations, including issues that a psychological theory should address, the theoretical alternatives as they now stand, and the research strategies that have tested these various alternatives. Chapter 2 outlines the main empirical findings to date, and frames the hypotheses about lexical disambiguation that motivated the present research. Chapters 3, 4, and 5 present eight experiments that tested these hypotheses, and Chapter 6 summarizes and discusses their implications for current theory.

Linguistic aspects of lexical ambiguity

Lexical ambiguity is one of three forms of semantic ambiguity in natural languages: phonetical, grammatical, and lexical (see Ullman, 1972, for a discussion). Phonetical ambiguity occurs if the phonetics of an utterance are consistent with more than one interpretation, and occurs because breath-groups, rather than single words, are the acoustic units of continuous speech. For example, an arrow and a narrow are phonetically ambiguous in this sense. Grammatical ambiguity can be found either at the level of individual grammatical forms or at the level of sentence structure. Individual forms can have different meanings; for example, the prefix "in-" can signify negation, as in inappropriate, or can mean "from within", as in inborn. Individual forms can also make indefinite reference, as for the pronoun you, which can have either a singular or plural referent. Ambiguities at the level of sentence structure are well documented and discussed in the psycholinguistic literature (Fodor, Bever, & Garrett, 1974). For example, a sentence like Flying planes can be dangerous is semantically ambiguous because it can be parsed to yield different meanings.

Lexical ambiguity occurs if a word represents either a number of closely related concepts or two or more entirely different concepts. The distinction between "closely related" and "entirely different" concepts is roughly captured by the lexical distinction between polysemy and homonymy (although there are also etymological criteria for the application of these terms). Polysemy refers to cases in which the same word has a number of meanings that are closely related to the same concept. For example, board can mean "a thin plank", "tablet", "table", "persons sitting at a council table", etc. Similarly, line can be used in the sense of a "line of sight", a "line of kings", a "line of duty", a "line of thought", etc., all of which seem to revolve around the central concept "something one-dimensional connecting two points" (see Miller, 1978). There is scarcely a content word in English that escapes polysemy if the notion is defined broadly enough.

Homonymy refers to cases in which two or more different words are identical in spelling or sound and have meanings related to different concepts. For example, seal can mean, among other things, "any of numerous marine aquatic carnivorous mammals" or "something that firmly closes or secures". Homographs are homonyms having identical spelling, but for which pronunciation may differ (e.g., refuse, meaning either "garbage" or "to show or express a positive unwillingness to accept or comply with"). Homophones are homonyms that have identical pronunciations and different spellings (as in hear and here; all and awl; and to, too, and two), but homophony can also apply purely at the semantic level; homographs that are pronounced identically for each meaning are homophonic in this broader sense. Because homographs that are homophonic have convenient properties for studying lexical ambiguity in the visual modality, attention is restricted to these homonyms.

Is there a theoretically important distinction between polysemy and homonymy for a psychological theory of lexical disambiguation? On purely etymological criteria, polysemy and homonymy are sometimes difficult to distinguish if the semantics of a single, polysemous word exhibits historical divergence between two or more meanings sufficient to destroy the conceptual unity of the original word (Ullman, 1972). For example, words like mean ("middle" or "nasty") and sole (name of a fish and part of a shoe) have become homonyms by historical convergence. Etymological distinctions aside, what seems to be of psychological importance is the distinction between polysemy and homonymy as ideal types because, as lexicographers are aware, a true homonym is entered in a dictionary as two or more distinct entries, whereas polysemy requires elaboration of different, related senses of a single entry. Therefore, a truly polysemous word has a single core sense, but a truly homonymous word has multiple core senses. To the extent that the metaphor of a dictionary is used by psychologists to define structural and/or processing parameters of a mental dictionary or mental lexicon, true homonymy presents a different problem than true polysemy.

To illustrate, a proposal was made by Miller (1978) for a mental representational scheme for polysemy in which a single core sense is retrieved, and some contextually-sensitive process acts on this core sense to derive a specific meaning or instantiation. Miller offered this model in the interest of preserving the representational economy of the mental lexicon, which comports with a traditional view in linguistics that "[i]f it were not possible to attach several senses to a word, this would mean a crushing burden on our memory: we would have to possess separate terms for every conceivable subject we might wish to talk about (Ullman, 1972, p. 168)." Applying such a model to the representation of homonymy is a more radical thesis about memory retrieval than for polysemy. Ullman (1972, p. 180-181) notes, for example, that "...it is impossible to imagine a language without polysemy, whereas a language without homonyms is not only conceivable, it would in fact be a more efficient medium." This is, of course, because homonymy entails multiple core senses; the different senses cross semantic boundaries, rather than being elaborations on a single core sense. It can therefore be asked: Would all of these different core senses be initially retrieved independent of context, or would a contextually-sensitive process constrain which core concept was retrieved? The retrieval of different core senses independent of context is a radical thesis about memory retrieval. It is contrary to the notion that information in semantic memory is addressed by virtue of its semantic content (Wickelgren, 1981); that is, that memory is organized and interrogated in terms of semantic concepts (or semantic fields, Miller & Johnson-Laird, 1976; or schemata, Schank, 1972; see Kintsch, 1980). Just such content-independent retrieval has been taken to characterize the mental lexicon, a proposal on which the present experiments will focus.

Whatever the case, just how relevant lexicographic considerations are to psychological theorizing depends on how far one takes the analogy between the interrogation of a physical dictionary and the interrogation of a mental dictionary. Suffice it to say that, as far as types of lexical ambiguity are concerned, true homonymy represents a test case that pure polysemy does not.

Psychological aspects of lexical ambiguity

A psychological model of lexical disambiguation requires the postulation of various structures and/or processes mediating the retrieval of meanings of individual words in an ongoing linguistic environment. Such a requirement has been taken by many psychologists to be part of the program of research into semantic memory. The dominant theme in the past ten years of this program of research (Kintsch, 1980; Smith, 1978) is that the theory of semantic memory must account for four kinds of processes in language comprehension: (1) the retrieval of the semantic representations, or meanings, of individual words (lexical access); (2) the combination of word meanings to generate the meaning of sentences (combinatorial processes); (3) the relating of these meanings to the world, that is, those processes which mediate judgements of truth or falsity (referential processes); and (4) the extrapolation from the meaning of utterances to other knowledge (inferential processes).

Words as units of analysis

On the foregoing view, words and their individual meanings are taken to be basic units of analysis, comprising an integral data base that can operate autonomously (Forster, 1979) from higher levels concepts like "semantic fields" (Miller & Johnson-Laird, 1976) or "frames" (Minsky, 1975; Schank & Abelson, 1977). If the various levels of analysis (retrieval of word meanings, and combination of these to yield the meaning of higher-level units, like sentences) are accepted, the task for a theory of retrieval from semantic memory is to specify these interactions in more detail, specifically with respect to what information is involved and when they occur. The present research falls squarely within the tradition that treats words as a basic unit of analysis. Such an assumption need not be adopted (see Kintsch, 1980; Wickelgren, 1981, for criticisms), but an integral data-base of information about words (passively conceived) is still compatible with a variety of interactions among levels of representation, and does not necessarily entail a static, hierarchical system. Even Kintsch (1980), who is critical of the traditional program, has argued that reading includes enumeration of the possible senses of a word ("sense activation") before general knowledge and context is consulted to <u>select</u> one of the activated senses ("sense selection"; Kintsch & Mross, 1985). Therefore, the divisions representing the domains of semantic memory theory offered by Smith (1978) are best taken programmatically, because they seem to represent intuitively-appealing levels of cognitive process and structure. How these different levels actually interface is still an empirical question. What is clear is that no progress can be made on the problem of lexical disambiguation, or, for that matter, word recognition in general, if no assumptions are made about what constitutes a level of representation called lexical memory and what processes retrieve information from it.

The Mental Lexicon

The common strategy in psychological investigations of word meaning and word recognition has been to suppose (1) that there is information stored in memory about each word in a person's vocabulary, (2) that the store of information is structured or organized in some fashion, possibly like a dictionary or some hierarchical structure, and (3) that some process of retrieval recovers some or all this information whenever a word is recognized. The contents and structure of this corpus of linguistic information has been called the mental lexicon, and the process of retrieval from the mental lexicon, lexical access. Each of the foregoing assumptions will be briefly discussed to acquaint the reader with the issues raised by the notion of a mental lexicon.

Information in the lexicon. The ways in which we use words suggest a variety of information that could be stored in a mental lexicon. Recognizing spoken words requires phonological information; spelling or recognizing written words requires orthographic and morphological information; using words grammatically requires syntactic and grammatical-class information; using words appropriately in discourse requires semantic information, like a word's definition, the concept it expresses, and the semantic contexts in which it can be used. The list of kinds of information can be further extended to include what has been termed the "pragmatics" of words (Miller, 1978), which is their relation to general knowledge or to discourse contexts.

A central problem for the theorist of semantic memory is to specify the kinds of information comprising the mental lexicon proper. Specifically, as far as the semantics of the mental lexicon is concerned, at what point does purely lexical information end and more general knowledge begin? The question has often been cast in terms of the distinction between information contained in a dictionary (word meaning) and that contained in an encyclopedia (general knowledge). One extreme answer to this question is that the lexicon and general knowledge are continuous, that accessing an entry in the mental lexicon entails accessing all that we can say about it. On this view, there are indistinct boundaries between levels of representation, implying that general background knowledge can interact with the stimulus information in words to directly access meaning. As will be seen, this view naturally comports with the idea that a single meaning of a lexical ambiguity can be selectively retrieved on the basis of information in the context, because interactions can occur in the system that systematically constrain the scope of retrieved information.

Others have responded to this proposal by arguing that the mental lexicon could not be synonymous with all our knowledge about words because this would include many subtle shades of meaning that a lexicographer could generate, as well as all those meanings that could be inferred on the basis of the concepts expressed by the vocabulary. As alluded to in the foregoing discussion of Miller's (1978) mental representation of polysemy, this view often conceives the mental lexicon as a relatively stable and passive store (Miller, 1978) in which certain "core" concepts reflecting the meaning of familiar words are stored, and that these core concepts are first retrieved and made "available for use by the more active [inferential, constructive] components of the information processing system involved in language use" (Miller, 1978, p. 62). This view of information in the lexicon is consistent with the notion that the lexicon accepts characteristic "inputs", like the spelling pattern of a word, and delivers characteristic "outputs", like all the meanings consistent with that spelling pattern. So, wheras a lexicon that is co-extensive with our general knowledge leads naturally to a strong contextualism, a lexicon that is "modular" (Fodor, 1983) leads naturally to the view that some processes in memory are independent of context. Both of these views of the mental lexicon have counterparts in models of the resolution of lexical ambiguity.

Organization of the lexicon. The traditional program for the theory of semantic memory has the task of giving an account of the organization of the mental lexicon in terms of the concepts expressed by words. Such an enterprise is predicated on an adequate account of word meaning, something for which there is, at present, no generally accepted theory (see Johnson-Laird, 1983, for a discussion). A consideration of proposals about the organization of the mental lexicon is beyond the scope and interest of the present work. By and large, theories of the organization of the lexicon have relevance for the resolution of lexical ambiguity inasfar as they imply contextually-based selectional restrictions on which meaning is retrieved. For example, one of the original proposals is the theory of semantic markers. In the first version (Katz & Fodor, 1964), the mental lexicon was taken to decompose the meanings of words into semantic components, in particular, into sets of necessary and sufficient conditions. The meaning of the word woman, for example, would be the basic concepts human, female, and adult, none of which is decomposable into further more primitive concepts. To interpret the meaning of a sentence, the meanings of individual words are combined, subject to selectional constraints that one word's meaning imposes on other words. As such, lexical ambiguity would be resolved by virtue of information in the mental lexicon that specifies the semantic context in which a word can appear. For example, the entry for bowl might be:

bowl 1. (an artifact, noun) container from which to eat food.

2. (an action, verb) to propel a ball on a surface in order to knock down pins.

Thus, the sentences The group decided to bowl and He ate from the bowl would thus each constrain the interpretation of the word bowl by virtue of the restrictions placed upon its different uses by other words in the sentence. Given the selectional constraints imposed by context, a single interpretation of a lexical ambiguity would be retrieved.

Other models of the organization of the mental lexicon might be proposed that would entail that more than a single meaning of a lexical ambiguity is retrieved, even in a biasing context (see Johnson-Laird, 1983; Kintsch, 1980; Smith, 1979, for reviews). The alternative models of lexical access of interest in the present work will be discussed below. As far as the organization of the mental lexicon is concerned, the important point is that whether access to a single, contextually-appropriate meaning of a lexical ambiguity is possible depends on how much constraint is imposed by context on retrieval from the lexicon proper. The necessary constraints can either be built into the lexicon (as in semantic marker theory), or provided by information external to the lexicon, to which retrieval from the lexicon is sensitive. If access to the lexicon is constrained by either means, then selective access to a single meaning of a lexical ambiguity is possible. If, on the other hand, lexical access is not semantically constrained, but is sensitive to only, for example, the spelling pattern, this will entail the retrieval of multiple meanings associated with that pattern, one of which is selected by processes external to the lexicon.

Retrieval from the lexicon. A final general assumption about the mental lexicon is that some process of retrieval, called lexical access, recovers information about a word's meaning. Two kinds of retrieval processes can be distinguished that will figure in the subsequent discussion, often both referred to, equivocally, as "lexical access". One sense of lexical access refers to those processes in which some memorial representations of meaning have been "contacted", "activated", or otherwise raised above some baseline level, a process that can occur outside of conscious awareness. Various performance indices (like reaction time) have been used to infer that information has been accessed in this sense (Posner, 1978). This kind of memory access is often conceived as a passive "spread of activation" through some memorial structure, like a network of associations, a process described as "automatic" (outside of an individual's conscious control) and excitatory (i.e., inhibitionless). One helpful way to think of this kind of lexical access is in terms of memorial generalization: Activity in one "portion" of memory automatically produces activity in another because they share some common link. An important characteristic of this kind of memory access is that the amount of activation can be graded: Any representation that has been activated above some baseline, no matter how little, has been accessed or retrieved in this sense. This is the sense of lexical access specified in Morton's (1969, 1970) logogen model and in Posner's (1978) notion of "pathway activation."

"Access as activation" can be distinguished from "access as selection", where the latter refers to processes that select amongst a variety of activated components. The process of selection can be thought of as the discriminative side of memory retrieval, the end product being that an individual becomes aware of some unique outcome, viz., a single meaning. This side of retrieval is often characterized as involving inhibition, because non-selected, yet initially accessed, components would need to be suppressed to allow only a selected meaning into awareness.

Some models of word recognition stress either one or the other kind of retrieval, whereas others use both. For example, "directed search" models, exemplified by the "ordered search" model of lexical disambiguation (e.g., Forster & Chambers, 1973; see below), posit that meanings are searched for and evaluated in turn as they are located in memory; there is an active, discriminative search throughout the whole process of retrieval. Some models rely heavily on "passive" activation (e.g., Morton, 1969) in which the meaning with the highest activation level (above some threshold) is automatically the one of which we become aware. Still other models include both passive and active components (e.g., Becker, 1980; Neely, 1977), the passive component accessing some set of meanings from which the active component selects one. The present work is particularly concerned with the view which isolates two processes in interpreting a word's meaning (see Clark & Gerrig, 1983; Neely, 1977): A process that rapidly and effortlessly retrieves well-learned, core senses ("sense activation") and a process that more slowly and laboriously selects a contextually-specific sense (sense selection; Kintsch and Mross, 1985).

One further question arising from recent approaches to lexical retrieval deserves mention, although this view has not as yet been seriously explored in the literature on the resolution of lexical ambiguity. The question revolves around whether retrieval processes always consult a stable, passive, lexical memory (the mental lexicon) in the course of determining the meaning of a word, or whether a more flexible, episodic memory is either consulted independently, or somehow influences retrieval from, a more stable lexical store (semantic memory; see, for example, Feustal, Shiffrin, & Salasoo, 1983; Jacoby & Brooks, 1984; Tulving, 1983). If episodic memory influences, or is even an integral part of the perceptual analysis of lexical items (Jacoby & Brooks, 1984), the nature of retrieval from the mental lexicon as discussed here must undergo revision. Suffice it to say at this point that the "standard" assumptions about retrieval from a stable mental lexicon have been questioned, despite the fact that, on the whole, the present work has proceeded in light of these. This issue will re-appear in Chapter 5.

General Research Strategy in the Literature

Psychologists have generally approached the problem of lexical disambiguation by pursuing the normal speaker's intuition that contextual information provides the constraint necessary to select a single meaning. This has included giving an empirical answer to two questions. First, what are the different sources of contextual information that could constrain our interpretation of a lexical ambiguity? Second, how do these sources of information interact to determine a single interpretation?

Constraining Information

Various kinds of constraining information have been studied experimentally, and these will be reviewed in detail in Chapter 2. Consider briefly the candidates. There are two classes of information that could play a role in lexical disambiguation: (1) grammatical and semantic information differentially associated with the meanings of a lexical ambiguity, called "lexical structure" (Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982), and (2) grammatical and semantic information in the immediate or more general linguistic context.

Lexical structure. There are three kinds of information identified with lexical structure. First, the meanings of some lexical ambiguities belong to different syntactic classes. For example bowl and rose have both noun and verb readings, and the distinctive syntactic contexts in which they appear can be disambiguating. Second, lexical ambiguities differ in terms of number of meanings. Some, like foil, have many meanings (to defeat or repulse, an incomplete fall in wrestling, a fencing weapon, metallic paper, etc.). Others, like bat, have two principal meanings (baseball bat and vampire bat). If some parameter of retrieval from lexical memory were associated with number of meanings, this would be a relevant psychological variable for a theory of disambiguation. Third, the meanings of lexical ambiguities differ in terms of their relative frequency of occurrence in a person's experience, called meaning dominance. If greater familiarity with a meaning were to facilitate its retrieval from lexical memory, this too would be a relevant psychological variable. (Meaning dominance is technically not information "internal" to the homograph, as are syntactic class and number of meanings. Rather, meaning dominance is a function of the general context of a person's linguistic experience. Nonetheless, immediate linguistic context would presumably not be required for this information to exert its effect.)

Linguistic context. Linguistic context refers to a wide variety of specific and general information that can potentially disambiguate words. One kind of information in the linguistic context is syntax. For example, the syntax of sentences like "They all rose in unison" and "We were warned to refrain from doing it" can specify the part of speech of the lexical ambiguity, thereby constraining which meaning is assigned. The important informational candidate in the general or immediate linguistic context is semantic information, because it can evoke one or more concepts sufficient to limit which of the possible meanings of a homograph is plausible. This kind of contextual information is most often simulated in experiments by using words, sentences, or paragraphs that immediately precede a lexical ambiguity. Even more general is the context of a person's experience with words, and this can be simulated in experiments by using special experimental arrangements that examine the probabilistic structure of normal experience with words (meaning dominance). For example, the same word can be repeated in an experiment to study the effects of frequency of exposure. Or, different words related to a single concept can be repeated over trials to assess the constraining effects of evoking concepts closely related to one meaning of a lexical ambiguity (e.g., cereal... breakfast... table... spoon... bowl).

Many of these kinds of information have been used in experiments to test various models of ambiguity resolution, experiments that are reviewed in Chapter 2.

Interaction of Information

The second research question prompted by the normal speaker's intuition that context constrains interpretation of a lexical ambiguity is "How do the various sources of constraining information interact to render a unique interpretation of a lexical ambiguity?"

Three perspectives on the interaction of information have been offered: selective access, ordered access, and exhaustive access. The three perspectives can be distinguished by their different answers to the question "Is a lexical ambiguity a local semantic uncertainty in an utterance?" If a decision about the meaning of a lexical ambiguity is always required at the time of its occurrence regardless of various constraints in the context, there is local semantic uncertainty associated with its processing. If constraints in the context obviate the need for a decision about the meaning of a lexical ambiguity, there is no local semantic uncertainty associated with its processing; its meaning is directly retrieved. Therefore, the psychological question is whether the processing of ambiguous words always begins with some local uncertainty, possibly because of properties of the lexicon proper (like its informational structure and the nature of retrieval from it), or whether constraining information eliminates any local uncertainty by taking one directly to a single meaning. Let us examine each of these alternatives.

Selective access. At one extreme is the view that a lexical ambiguity is not a local semantic uncertainty because information in the context constrains retrieval to a single meaning (Schvaneveldt et al., 1976). Contextual information, usually from the immediate semantic context, is taken to interact with stimulus information (the spelling pattern of the word) so as to provide direct access to a single meaning.

Support for selective access requires demonstrating that there are conditions in which the processing of an ambiguity is limited to a single meaning. Demonstrations have included showing that even a single word context can constrain processing of a homographic word to a single meaning (Schvaneveldt et al., 1976). Selective access has received surprisingly little attention in research on lexical ambiguity, despite the fact that "[t]his model is more compatible than others with those general models of word recognition that depend on the concept of semantic distance and emphasize the sensitivity of lexical access to manipulations of context" (Simpson, 1984, p. 317). This is not to say that the role of context has not been evaluated, but it has usually been in the service of testing what seems to be the more generally accepted view that multiple meanings are always accessed.

An important feature of selective access - one often not recognized in the literature - is that, because context is taken to provide the necessary semantic constraint for direct access to a single meaning <u>and</u> context can vary in the <u>degree</u> of constraint it imposes, the model is compatible with more than one meaning being accessed under conditions in which there is no context, weak context, or conflicting information in the context. The "garden path" phenomenon, in which an ambiguous word is initially interpreted in terms of one source of contextual information and later revised in light of the whole context, is an example of multiple meanings being accessed, presumably in a serial fashion, given conflicting sources of information. For example, "The astronomer married the star" entails a garden path in which more than one meaning of <u>star</u> is accessed because of conflicting contextual information: "Astronomer" is compatible with the "heavenly body" sense of star, which is also the dominant meaning of star, but the verb "married" imposes a selectional restriction of "being human" on the object.

<u>Exhaustive access</u>. At the other extreme of the

"local uncertainty continuum" is the view that a homograph is always a local semantic uncertainty in a sentence. On this view, each time a lexical ambiguity is encountered, there are disambiguation procedures for selecting a single meaning from among its exhaustively accessed meanings.

The theoretical underpinnings of this view are detailed, related to the ideas that (1) perceptual processing of a word proceeds "automatically" to the deepest level for which there are well-learned semantic representations (the late-selection theory of attention: see Deutsch & Deutsch, 1963; Norman, 1968), and (2) the mental lexicon is a data base that is autonomous from other levels of processing in the system, having structures and processes internal to it which access contextually-inappropriate semantic representations (Forster, 1979).

Exhaustive access has typically been defended in the context of the two-factor theory of attention (Neely, 1976, 1977; Posner & Boies, 1971; Posner & Snyder, 1975), an offshoot of the late-selection theory of attention. The two-factor theory argues that perceptual analysis of well-learned stimuli is rapid, capacity-free, and carried on outside of and prior to awareness (i.e., is pre-attentive); together these criteria identify what is called "automatic" processing. Whereas perceptual analysis proceeds in an unlimited-capacity cognitive environment, response selection and execution require capacity, making them slower, prone to mental resource limitations, and sensitive to contextual factors, including transient interpretive strategies.

The two types of processing have been taken to constitute two, sequential stages that characterize the process of lexical disambiguation: a process that accesses meanings and a process that selects a single meaning from the accessed set. The access process might be construed as a parallel process or serial process (Onifer & Swinney, 1981), but no attempt will be made in the present context to distinguish these alternatives, if this is even possible (see Townsend, 1974). More important is the notion that access is independent of biasing contextual information and, according to Onifer and Swinney (1981), the relative dominance of meanings. Contextual information is taken to exert its effect only after perceptual analyses have accessed all semantic representations compatible with the ambiguity. Only the products of the selection process are admitted to consciousness, which accounts for our typical lack of awareness of lexical ambiguity.

Support for exhaustive access, conceived as a two-stage process, requires demonstrating that there are in fact two stages with different properties, the first stage being immune to the effects of context and the second stage dependent on context (or other biasing information). Therefore, whereas the challenge for defenders of selective access is to show that only a single meaning is accessed under at least some circumstances, the challenge for defenders of exhaustive access is to show that multiple meanings are accessed under all circumstances.

Ordered access. The ordered-access view (Forster & Chambers, 1973; Hogoboam & Perfetti, 1975; James, 1975; Rubenstein, Garfield, & Millikan, 1970; Rubenstein, Lewis, & Rubenstein, 1971) lies somewhere between the selective- and exhaustive-access views on the issue of local uncertainty. Local uncertainty derives from the fact that meanings in the lexicon are always accessed serially in an invariant order, beginning with the dominant meaning and followed by other meanings in order of frequency. After a meaning is accessed, a comparison process or decision stage evaluates the consistency of an accessed meaning with the context. A comparison that produces a match with the context terminates the search process, whereas a non-match prolongs the search process until all meanings have been accessed and compared. Ordered access is thus conceived as a serial, self-terminating search with two components: an order of search that is invariant and a termination of search that is sensitive to context.

Given such an ordering of access, one would expect to find evidence for more than one meaning being active if a context biases a subordinate meaning, because all higher-dominant meanings would have been searched to find one that matches the context. If, on the other hand, a context biases the dominant meaning, or there is no biasing context, the search terminates with the dominant meaning and no evidence for access of subordinate meanings would be found. Evidence for ordered-access has therefore come from demonstrations that the dominant meaning of a homograph is processed before a subordinate meaning.

The various models of the interaction of information in the cognitive system have been characterized as mutually exclusive, reflecting to some extent the bias of researchers to describe the cognitive system in terms of a monolithic architecture. The cognitive system may, however, be flexible enough to accomodate all three models in some form. For example, it may be that the effect of variables like meaning dominance exert a powerful effect only if context is not sufficiently constraining to overcome their effects. In this vein, Simpson (1981; see also Carpenter & Daneman, 1981) has offered a somewhat modified version of the strict view of search ordered by dominance, arguing that a very strong semantic context can overcome the effects of meaning dominance and provide direct access to a contextually-appropriate meaning. Others have argued that exhaustive access occurs in the absence of a strong context; otherwise access is selective.

Summary

Lexical ambiguity occurs if two words share either spelling, pronunciation, or both, and specify different concepts. The task for a theory of lexical disambiguation is to postulate memorial structures and processes that account for how a single meaning of a lexical ambiguity is determined. A central theoretical construct serving this end is the "mental lexicon", a lexical form of memory characterized by informational content, structure, and retrieval processes. The central research tactic has been to determine the constraining effects of lexical structure and grammatical/semantic context on access to the mental lexicon. All views about how this interaction occurs place an important emphasis on context in disambiguation, but they differ with respect to how context is used, in particular, how much local semantic uncertainty is associated with the processing of a lexical ambiguity. In selective access, context can limit access to a single meaning; hence, there need be no local semantic uncertainty. Both exhaustive and ordered access posit a contextually-invariant process, such that a lexical ambiguity is always a local semantic uncertainty in an utterance. For ordered search, local uncertainty exists because the mental lexicon is entered at the same place (the dominant meaning) and searched in the same fashion (from dominant to subordinate meanings) regardless of context. For exhaustive access, local uncertainty exists because the mental lexicon is always entered via the spelling pattern; all entries compatible with this pattern are accessed regardless of context.

Chapter 2

REVIEW OF RESEARCH

> Conflict is to be expected as different paradigms seek evidence for this fleeting multiple-activation pattern.
>
> Posner (1978, p. 95)

Two general experimental paradigms have been employed to study the processing of homographs. In <u>on-line performance</u> tasks, a variety of procedures are used which assess processing of homographs right at, or close to, the presentation of the ambiguity itself (see Simpson, 1984, for a review). Typically, homographs are presented either singly or in word or sentence contexts, and the relatively local impact of the presence of the homograph is assessed by measuring time to respond to either the homograph, a phrase or sentence including the homograph, or some stimulus that is temporally contiguous with the homograph, like a word related to one of its meanings. In <u>episodic memory</u> tasks, the conditions under which homographs are studied and later tested are varied, and inferences about encoding and retrieval are based on patterns of recall or recognition. Although each method has been taken to address an independent set of outcomes (roughly, outcomes associated with accessing operations versus those associated with selective operations; see Warren, Warren, Green, & Bresnick, 1978), the different procedures must eventually produce results that are consistent.

The principal results and implications of each of these procedures will be reviewed, followed by a statement of the central problems as they now stand.

On-line performance tasks

The preponderance of experimental studies of lexical ambiguity have attempted to infer how homographs are processed from measures taken right at, or close to, a homograph's presentatation. Three principal procedures have been used, each with characteristic assumptions. Processing complexity tasks assume that homographs require more complex processing than non-homographs. Ambiguity detection tasks assume that memory organization and retrieval are revealed by the time taken to search for and produce the alternative meanings of a homograph. Finally, semantic priming tasks assume that what meanings have been accessed will influence the speed of response to words that are related to a homograph's different meanings.

Processing complexity tasks. Processing complexity tasks are based on the rationale that, if more than a single meaning of a homograph is processed, a homograph should require more complex processing than a non-homograph, and this should be evidenced by a relatively local, transient processing load produced by the homograph in a sentence. Olson and MacKay (1974), for example, found that it took longer for subjects to complete a sentence fragment, or to judge the truth of a sentence, if it contained a homograph rather than a non-ambiguous control word. Holmes (1979) replicated the result using meaningfulness judgements, and also found that sentences presented word-for-word at a very rapid rate (16 msec/word) were recalled more poorly if they contained a homograph than a non-homograph, a result that obtained regardless of the semantic bias of the sentence. Assuming the equivalence of homographs and non-homographic controls in all other relevant features, these results would be expected only if more than a single meaning of a homograph is accessed during its processing.

Other experiments have qualified these results. Holmes (1979) found that if meaning dominance was manipulated, sentences biasing a subordinate meaning were judged to be meaningful more slowly than sentences biasing the dominant meaning, but only if the bias induced by the context was relatively weak. If the critical sentences containing the homograph (e.g., "The robber was chased from the <u>bank</u>.") were preceded by a strong context in the form of a sentence that biased one meaning (e.g., "The manager forced the robber to run out of the <u>building</u>."), the effect of dominance was virtually eliminated. Holmes concluded that, although dominance of meaning is a potent factor, it can be over-ridden by a strong context, a proposal consistent with selective access.

Carpenter and Daneman (1981) also examined the effects of meaning dominance and context, and predicted that the likelihood of assigning a particular interpretation depends on the combined effects of both these factors. Their procedure included visual presentation of priming sentences that biased one meaning of a homograph, and target sentences containing the homograph. The homographs they used were non-homophonic, that is, had different pronunciations for each meaning (e.g., tear as in "rip" or "droplet"), which made it clear which interpretation was assigned when read aloud. The duration of eye-fixation on words in the sentences, including the homograph, was also recorded. The results were that if two meanings of a homograph were roughly equi-dominant (symmetrical homographs), context was effective in biasing the pronunciation, but that as the two meanings departed from equi-dominance (became asymmetrical), there was an increased likelihood of pronouncing the homograph in its dominant sense, regardless of the context. Very infrequent meanings were virtually never pronounced, and even if strongly biasing contexts that included a synonym of the ambiguous word were employed (e.g., tailor...sewer), infrequent meanings were pronounced only 20% - 30% of the time.

Carpenter and Daneman (1981) posited a model in which access includes retrieval of multiple meanings as the different meanings approach equi-dominance, and that selection among the alternative accessed meanings is made on the basis of context. Conversely, as the meanings depart from equi-dominance, there is an increased likelihood that dominance alone will determine access, resulting, in the extreme, in access to only the dominant meaning regardless of context. The latter situation will, most of the time, result in an exaggerated garden-path search to resolve the ambiguity. Thus, on their view, dominance of meaning and context trade off against one another, with context unable to tip the balance in its favour if a subordinate meaning is extremely infrequent. Carpenter and Daneman's model, in giving such an important role to dominance, appears most consistent with ordered access. However, the model is quite different. Two distinct stages are hypothesized for disambiguation. On presentation of the homograph, each meaning is activated in parallel to a base level of activation associated with its relative dominance, a base level that can also be increased by spreading activation from prior semantic context. If the level of activation exceeds some threshold level (see Morton, 1969, 1979), the meaning enters an integration or selection stage for comparison with the syntactic and semantic information in the context. Thus, for symmetrical homographs, more than a single meaning can be submitted for selection because more than one exceeds threshold on the basis of dominance alone; for asymmetrical homographs, although the subordinate meaning may be weakly activated initially, it is unlikely to reach threshold and be submitted for selection. Importantly, it is only if multiple meanings are submitted to the selection stage that multiple access occurs, which is why the model posits that multiple meanings are accessed for symmetrical homographs, but not for asymmetrical homographs, for which direct access to the dominant meaning occurs.

Another processing complexity procedure is the phoneme monitoring task. Here the subject attempts to detect a target phoneme in a sentence presented auditorily, and on the critical trials the phoneme is part of a word that immediately follows a homograph. Phoneme detection times should be longer following a homograph than a non-homograph if the homograph requires longer processing based on multiple access. This result was found by Foss (1970), and was also shown to obtain if one meaning of the homograph was biased by the sentence (Foss and Jenkins, 1973). However, Swinney and Hakes (1976), using very strongly biasing sentences, failed to obtain a different between homographs and non-homographs, arguing that a strong context is sufficient to provide selective access.

This conclusion, however, was further qualified by Cairns and Kamerman (1975) and Cairns and Hsu (1980) on the basis of distinguishing two stages in disambiguation: access to meanings and selection of one. Cairns and Kamerman showed that slower detection times for phonemes preceded by homographs were dependent on the delay between the homograph and the phoneme. If the delay was short, the detection times were slower in the homographic case, consistent with exhaustive access; if the delay was longer (several syllables after the homograph), detection times were equal in the homographic and non-homographic cases, a result consistent with selective access.

Unfortunately, results from phoneme monitoring have been called into question by the demonstration that the procedures included a confounding with word length (Mehler, Segui, & Carey, 1978) and with phonological similarity between the homographs/non-homographs and the target phonemes (Neuman & Dell, 1978). Despite this fact, the important distinction between access and selection was drawn on the basis of these data, and it was left to research using another on-line performance task, semantic priming, to vindicate its importance. Before discussing semantic priming, brief mention will be made of ambiguity detection, a procedure that has been criticized for ignoring the distinction between access and selection (Simpson, 1984).

Ambiguity detection tasks. As the name implies, ambiguity detection requires subjects to determine whether a word is ambiguous and assumes that conscious detection of ambiguity reveals the organization of, and retrieval from, lexical memory (Forster & Bednall, 1976; Foss, 1970; Hogoboam & Perfetti, 1975; Holmes, 1979; MacKay & Bever, 1967; see

Simpson, 1984, for a discussion). The principal finding of the procedure is that lexical ambiguity is detected more rapidly if a context biases a subordinate meaning than if it biases a dominant meaning. Such a result would be expected if understanding a lexical ambiguity in a subordinate sense entails that the dominant meaning has already been accessed, whereas understanding an ambiguity in its dominant sense requires additional search for a subordinate meaning. Although these studies were important in bringing attention to the variable of meaning dominance, ambiguity detection is unable to distinguish between processes that determine conscious report and those that initially interrogate the lexicon. This has been taken to be one of the principal virtues of semantic priming tasks.

Semantic priming tasks. The rationale for semantic priming tasks is that information presented prior to a target stimulus (a word or sentence primer) will differentially affect responses to a target as a function of the degree of semantic relatedness between the primer and the target. For example, time to respond to a target word like doctor is shortened if one is put in the semantic vicinity of doctor by the prior presentatation of a word with a related meaning, like nurse, compared to prior presentation of either an unrelated word or some neutral stimulus (Meyer & Schvaneveldt, 1971). The advantage in response time afforded by a related primer compared to an unrelated or neutral primer is typically referred to as "facilitation".

The application of semantic priming to the question of disambiguation of homographs is straightforward. If a homograph is used as a primer, meanings that have been accessed can be inferred from the facilitation afforded to responses to target words. For example, if the primer bowl results in facilitation of responses to cereal (a dominant associate) and alley (a subordinate associate), then bowl must have included access to both meanings. Or, if responses to cereal preceded by a homographic primer, like bowl, were compared to responses to cereal preceded by a non-homographic primer, like breakfast, equal facilitation should obtain in the two cases if bowl always accesses the cereal meaning, and not some other meaning on some proportion of the trials. Furthermore, one can study context effects by priming the homographic primer itself with either a word or sentence (e.g., cereal - BOWL - alley, or "At breakfast he ate from the BOWL" - alley), and the effectiveness of the bias can be assessed by again measuring responses to various targets. Finally, one can examine what has already been mentioned to be an important variable, amount of processing time on the homograph, by varying either the interval between onset of the homographic primer and onset of the target, called the stimulus-onset asynchrony (SOA), or the interval between offset of the homograph and onset of the target, called the inter-stimulus interval (ISI). This latter procedure has thus far proved to be the most powerful, and popular, method for studying disambiguation.

Conrad (1974) reported one of the earliest applications of semantic priming, but with a slightly different twist than described above. The actual task was to name the colour of ink with which a word was printed. It has been shown (Dyer, 1973; Jensen & Rohwer, 1966; Stroop, 1935) that naming ink colours is slowed down if the ink forms a different colour word. For example, if the word blue is printed with red ink, the response "red" will be slower than if the word is the same colour name, red, as is the ink colour, or is a non-colour word, porch. The Stroop technique can be extended to non-colour words by varying the relative level of activation of the non-colour words using semantic priming, which correspondingly increases the colour-naming interference from the word (Warren, 1972). For example, the time to name the ink-colour of the word "cereal" can be inflated using a related primer (e.g., "bowl") compared to an unrelated primer, because colour-naming interference is taken to be mediated by the level of competing irrelevant activation of the word. Conrad applied just this technique by using sentence contexts ending with a homographic primer, immediately followed by a target word. She found that times to name ink-colours were inflated if the target words were related to either meaning of a homograph primer, compared to targets that were unrelated. Her conclusion was that multiple meanings are accessed. Unfortunately, the power of Conrad's demonstration was diminished because she presented each homograph a number of times to the same subject, thus confounding her results with repetition.

The same colour-naming procedure was adopted by Oden and Spira (1983), but their interest was to assess the relative impact of biasing a homograph using different kinds of context. A homographic primer was presented either alone ("TIRE..."; target: rubber or sleepy), in a syntactic context ("the TIRE..."), in a semantic context ("axle - wheel - TIRE..."), or in a sentence context ("Running over that glass could burst your TIRE..."). Contexts were either consistent or inconsistent with the meaning of the homograph reflected by the target. The results were as follows. (1) With only the homographic primer and no context, colour-naming interference was reliable and equal for both meanings; (2) with contexts biasing the same meaning as the target, colour naming interference systematically increased as the strength of the context increased; and (3) for contexts biasing a meaning different than the target, colour-naming interference tended to decrease with the strength of the context. Regarding this latter finding, the average interference for the context conditions was reliable, although none was individually reliable. The small but consistent colour-naming interference from contextually-inappropriate associates led Oden and Spira (1983) to conclude that all meanings are activated to some extent prior to the selection of one meaning, thus endorsing a two-stage view of disambiguation. The conclusion is not forced by their data, however; there was a mere 9 msec interference effect for inconsistent targets in the sentence context condition, so one might also conclude that strong contexts can provide selective access, but that Oden and Spira's contexts were simply not sufficiently constraining to do so.

Most research using semantic priming has employed the procedure in which a primer is followed by a target stimulus that is rapidly pronounced (a naming task) or about which a lexical decision is made (a decision as to whether a letter-string is a word or a non-word). Semantic priming studies of this variety will form the backdrop for the present experiments.

One of the earliest and most influential studies of disambiguation using semantic priming was by Schvaneveldt, Meyer, and Becker (1976). They asked the question: Does a word related to a homograph that is presented prior to the homograph bias its interpretation? Their procedure included presenting subjects with three letter-strings, each one requiring a lexical decision before presentation of the next. On the trials of interest, the first letter-string was a word related to one meaning of a homograph, the second was the homograph, and the third was either a word related to the same meaning of the homograph as the first, a word related to a different meaning, or an unrelated word. The result was that facilitation of response time to the final word obtained only if it was related to the same meaning as the initial biasing word; response time was the same for a word related to a different meaning and an unrelated word. Schvaneveldt et al. concluded that the prior word context determined which meaning of the homograph was retrieved, consistent with selective access; furthermore, they argued that in the absence of context, a single meaning is selected randomly from the possible meanings.

Subsequent studies have challenged Schvaneveldt et al.'s (1976) conclusions. Holley-Wilcox and Blank (1980) found evidence incompatible with the view that in the absence of a context a single meaning is randomly retrieved. They argued that if this were the case, one of two meanings of a homograph would be retrieved, on average, only half the time, whereas the single meaning of a non-homograph would be retrieved every time. They therefore predicted that if a homograph and non-homograph were primers for the same associate (BANK - <u>money</u> and COIN - <u>money</u>), lexical decisions about the associate would be facilitated on only half the trials with a homographic primer but on all the trials with a non-homographic primer, resulting in less overall facilitation using the homographic primer. Contrary to this prediction, they found equal response times using homographic and non-homographic primers, both of which were greater than an unrelated control, a result consistent with exhaustive access. The same finding has been reported by Seidenberg et al. (1982, Experiment 1) using homographs and non-homographs in sentence contexts and a pronunciation task.

Simpson (1981) reasoned that, although multiple meanings of isolated homographs might be retrieved if their respective dominances are equal, relative dominance might be associated with different degrees of activation. Using a procedure similar to Schvaneveldt et al. (1976), but only two stimuli (the homograph and target) instead of three, he found that the amount of facilitation was indeed greater for dominant than subordinate associates, the latter being no different than an unrelated control. Simpson also looked at the effects of sentential context. The sentences he employed were either ambiguous ("We had trouble keeping track of the COUNT"), weakly biased toward the subordinate or dominant meaning ("The king kept losing track of the COUNT" or "The musician kept losing track of the COUNT", respectively), or strongly biased toward the subordinate or dominant meaning ("My dog wasn't included in the final COUNT" and "The vampire was disguised as a handsome COUNT"). For ambiguous sentences, he found the same advantage for dominant over subordinate targets as in the no-context condition (e.g., number was categorized as a word faster than duke). For weakly biased sentences, the advantage for dominant targets still obtained if the sentence biased the dominant meaning, whereas dominant and subordinate targets were responded to equally fast if the subordinate meaning was biased. Finally, for strong bias, facilitation obtained only for contextually-congruous targets. Simpson argued that dominance and context act as independent factors in resolving ambiguity: Dominance determines access in the case of no context or an ambiguous context, context determines access in the case of a strongly biasing context, and both context and dominance determine access for a weak bias toward the subordinate meaning, the latter resulting in access to both the dominant meaning and the subordinate meaning.

A methodological innovation, partially prompted by the chronometric work of Posner and Snyder (1975) and Neely (1977), brought a great deal of order into the previous, apparently conflicting, findings: manipulation of the amount of time for processing the homograph. Neely (1977) demonstrated that there are two distinct effects of a priming stimulus on responses to a target, effects related to the amount of processing time on the primer before a response to the target (SOA). If the SOA were short (less than 300 msecs), he found that semantic relatedness between the primer and target resulted in facilitation of lexical-decision times, regardless of what the subject had been instructed to expect on the majority of trials. For example, time to respond to robin was facilitated by the categorical primer "bird" even if "bird" was expected to be followed on the majority of trials by a word from the category "building parts", like "door". On the other hand, if the primer was presented for a longer time prior to the target (SOAs greater than 300 msecs), an expected target was facilitated (bird - door) and an unexpected target inhibited, even if the latter was semantically related to the primer (bird - robin). If it is assumed that short and long SOAs control which of different processing stages of the primer exerts an effect on the target, subjects were initially accessing categorical information related to the primer before being able to use the primer as the basis for a semantically arbitrary prediction. This procedure and its associated theoretical rationale has provided a potent methodological tool for examining access to information that is contextually irrelevant.

Many studies have now appeared that compare time to respond to different associates of a homograph using short and long SOAs or ISIs (Kintsch & Mross, 1985; Marcel, 1980; Maxwell, 1981; Onifer & Swinney, 1981; Seidenberg et al., 1982; Swinney, 1979; Tannehaus, Seidenberg, & Leiman, 1979). The primary result of interest in these studies is that if the SOA is short (less than 300 msec), facilitation obtains for each of a number of meanings of a homographic primer, regardless of the semantic bias induced by a context, whereas if the SOA is long (greater than 300 msec), facilitation obtains only for associates that are related to the contextually congruous meaning of the homograph. Facilitation at short SOAs is taken as evidence for an initial, distributed-access stage, whereas facilitation at long SOAs is taken as evidence for a second, selection stage. For example, using a short SOA, the primer <u>pound</u> would facilitate responses to <u>ounce</u> and to <u>hit</u>, whereas <u>pound</u> would facilitate responses to only one of these, depending on the semantic bias of prior context. Demonstrations have typically used a cross-modal task in which a sentence containing a homograph (or a homophone) is read to a subject, and a visual target, requiring either lexical decision or pronunciation, is presented at various intervals relative to onset of the homograph. Contexts have included single words (Marcel, 1980; Maxwell, 1981), sentences with a syntactic bias (Swinney, 1979; Seidenberg et al., 1982), and sentences with a semantic bias (Onifer & Swinney, 1981; Kintsch & Mross, 1985), including sentences with words that are highly associated with the homograph.

The same pattern of facilitation across SOA has also been reported if the respective meanings of the homographs are of unequal dominance. Onifer and Swinney (1981) used asymmetrical homographs with a cross-modal lexical decision task similar to that described above. For example, the following sentence biased the dominant meaning of a homophone, fur/fir: "Their pet has very fluffy grey FUR all over him except on his two front paws and his tail, which are white with spots of black and brown". On the critical trials, either coat, pine, or an unrelated control word followed the homograph immediately (0-msec ISI) or after a delay (1500-msec ISI). Their result was that, regardless of the bias of the sentence, responses to dominant and subordinate associates were facilitated at 0-msec ISI, but only contextually-congruent targets were facilitated at 1500-msec ISI. On the basis of these data, Onifer and Swinney ruled out the possibility that access to meanings is accomplished by a serial, self-terminating search, as postulated by ordered access. Rather, they argued that the meanings of a homograph are exhaustively accessed, after which a decision is made about which meaning is most congruent with the context. If there is no biasing context, on the other hand, they posited that the dominant meaning is selected.

As Simpson (1984) correctly points out in his review of the literature, the essential issue that stands in need of clarification is the nature of the two hypothetical stages of disambiguation, access and selection. In particular, do meaning dominance and context exert their influence on initial access or on selection? A central purpose of the present experiments was to examine this question.

Episodic memory tasks

The variables of interest in memory studies have been meaning dominance and semantic context. Three studies are relevant, one demonstrating that homographs studied in isolation are encoded in their dominant sense (Winograd & Conn, 1971), one demonstrating that homographs studied in a semantic context are encoded in the sense biased by that context (Light & Carter-Sobell, 1970), and finally, one demonstrating that memory measures and on-line performance measures do not necessarily tap similar processes, and, by implication, that "access" to information in memory and "selection" of information from memory represent different processes with different effects (Balota, 1983).

Winograd and Conn (1971) asked the question: If a homograph is presented in isolation, what meaning will be encoded? They presented lists of single homographs in a study phase, and then tested recognition memory for the homographs in three different retrieval contexts: a sentence biasing the dominant meaning, a sentence biasing a subordinate meaning, or no context. Their result was that homographs were equally-well recognized in sentences biasing the dominant meaning and in isolation, both of which were superior to recognition of homographs in sentences biasing a subordinate meaning. Their conclusion was that, in the absence of biasing context, the dominant meaning of a homograph is encoded. Such a result is consistent with an ordered-access view.

Light and Carter-Sobell (1980) asked a question similar to Winograd and Conn's, but for context instead of meaning dominance: If a homograph is studied in a sentence context biasing one meaning, will subjects later recognize the same homographs if presented in contexts incongruous with the studied meaning? They reported that a switch in context was detrimental to recognition and argued that homographs are encoded in a sense biased by the study context.

Taken together, these studies are consistent with the conclusion that semantic context, or meaning dominance in the absence of context, determines the meaning encoded in episodic memory. As such, the data have usually been taken to support the selective access view. However, it is questionable whether the products of perceptual processing, namely the traces laid down in episodic memory during study and later retrieved at test, can be used to infer the processes by which the trace was originally established. As Warren, Warren, Green, and Bresnick (1978, p. 364) correctly note: "Evidence that only a single meaning of a word is available some time after processing is complete does not preclude the possibility that multiple semantic representations of the word were active and available earlier (p. 364)." Strictly speaking, then, the alternative views of the processing of homographs are not uniquely determined by the episodic memory data.

A study by Balota (1983) demonstrates this point nicely. Balota was interested in whether automatic activation in semantic memory influences the probability of an episodic trace being formed. Specifically, he asked whether automatically accessing the meaning of a homograph in semantic memory results in a bias in the episodic representation of that homograph. Light and Carter-Sobell (1970) had demonstrated that studying a homograph in a sentence context resulted in a biased episodic representation of the homograph, but their presentation procedure, which gave subjects plenty of time to study the homograph, necessarily included a complete perceptual analysis of the homograph up to selection. Balota simply asked whether access alone also produces an episodic bias.

In a study phase of the experiment, Balota used a lexical-decision task, and on the critical trials the target letter-strings were homographs. Homographs were preceded by primers that were either words related to one of two meanings of the homographic targets, unrelated words, or neutral stimuli (XXXXX). The amount of processing time on the primer was varied. On some trials, the primer was presented for a long duration before onset of the target, so that it could easily be seen and thereby maximally bias the interpretation of the homograph. On other trials, the primer was presented for a very brief time, and was followed by a pattern mask to preclude the possibility of the subject's seeing it and thereby produce semantic priming without subjects having any awareness of the biasing primer itself. The important result for the lexical-decision "study" phase was that reliable semantic priming obtained both for the condition in which the primer was clearly visible and the condition in which it was not visible.

Lexical-decision trials were followed by a recognition test in which the homographic targets were flanked by context words that were either congruous or incongrous with the originally studied meaning, a procedure similar to Light and Carter-Sobell's (1970). The question was how a change in context from study to test would affect recognition: If the episodic representation of the homograph was biased in the lexical-decision phase, then a change in context would be detrimental for recognition. Balota's result was that homographs originally presented with a clearly-visible primer suffered from a change in context, indicating that the study phase biased the episodic representation of homographs; on the other hand, homographs originally presented with the non-visible primer showed no effect of a switch in context between study and retrieval, indicating that no interpretive bias was established at study. Balota's conclusion was that momentary activation of a homograph's meaning in semantic memory does not bias which meaning is selected. Balota's experiment indicates, using a memory paradigm, that accessing information in the mental lexicon is quite distinct from selecting some or all of that information for the purpose of semantic disambiguation, and by extension, provides support for the notion that disambiguation includes two stages: access to meanings and selection of a meaning.

The Experimental Hypotheses

Experiments that have varied processing time on a homographic primer provide striking support for the view that disambiguation includes accessing operations that retrieve multiple meanings and selective operations that determine a contextually appropriate meaning. The present experiments focused on evidence for exhaustive access using procedures which examine ambiguity resolution over time.

Experiments 1 and 2 (Chapter 3) were designed to demonstrate that a homographic primer facilitates speed of pronunciation of both dominant and subordinate associates if the SOA is short, and facilitates speed of pronunciation of only the dominant associate if the SOA is long. The goal was both to replicate Onifer and Swinney (1981) using a different procedure - as a test of the hypothesis that both subordinate and dominant meanings are initially accessed - and to show that in the absence of context, meaning dominance is a factor determining which meaning is selected. An additional interest in the experiments was to test an alternative explanation of distributed facilitation at short SOAs. Koriat (1981) has argued that distributed facilitation is also consistent with selective access if at short SOAs an associated target exerts a selective influence on the homographic primer by "backward" priming a single meaning. Assuming that selection of a single meaning by a contiguous associated target will have memorial consequences, Koriat's proposal was tested by assessing the memorial bias in cued recall induced by the short and long SOA "study" conditions. The hypothesis was that, whereas there should be a dominant bias if the SOA at study is long - because the dominant meaning is selected, there should be a bias toward the target meaning if the SOA is short - because the meaning specified by the target is selected. For example, bowl would be a good cue for recalling only the dominant associate, cereal, if studied using a long SOA, whereas bowl would be a good cue for cereal and alley, if studied using a short SOA. Koriat's hypothesis was contrasted with the view (Balota, 1983) that, because accessing rather than selective operations mediate distributed facilitation at short SOAs, the normal bias to recall the dominant meaning will not be attentuated from a long to a short SOA.

Experiments 3 and 4 (Chapter 4) sought to further test the exhaustive access account by using a priming procedure in which the homograph is a target requiring a response, instead of a primer not requiring a response. Support for exhaustive access has primarily come from experiments that use homographs as primers and vary their processing time before a rapid response is required to a target. No experiments have satisfactorily tested exhaustive access by requiring a response to the homograph itself, and yet on this view, multiple meanings must necessarily be accessed in the course of responding to a homograph. As part of the rationale for the experiments, it was noted that there is a bias to pronounce the dominant meaning of a homograph (Carpenter & Daneman, 1981), which of course means that the dominant meaning is selected. Given exhaustive access, responding to a homograph - even in its dominant sense - entails that subordinate meanings must also have been accessed prior to the dominant meaning being selected. Based on this, a rationale in terms of Stroop-like interference was developed about the pattern of response times to homographs primed by associates. It was hypothesized that at short SOAs a subordinate primer should interfere with time to pronounce a homograph, whereas a dominant primer should facilitate time to pronounce a homograph. It was also expected that this effect would be limited to short SOAs if the Stroop logic were sound. A number of other experiments in the literature (e.g., Balota, 1983) using similar procedures provided the basis for specific predictions about the facilitative effect of associated primers on responses to homographs at a long SOA.

Whether exhaustive access is the correct account of the processing of homographs depends on how immune the hypothetical accessing operations are to manipulations of context. If facilitation of response time at short SOAs reflects a context-independent retrieval process, then this facilitation should obtain regardless of prior encoding operations on homographic primers. The problem with previous manipulations of context is that they have not tested the limits of exhaustive access by using the strongest contexts possible. Experiments 5a, 5b, 5c, and 6 (Chapter 5) required subjects to first study homographs in either their subordinate or dominant sense, and then used the same homographs as primers at short SOAs in a reaction-time task (lexical decision in Experiments 5a, 5b, 5c, and pronunciation in Experiment 6). Therefore, whereas Balota (1983) asked whether automatic priming results in episodic bias, these experiments asked whether episodic bias affects automatic priming.

Chapter 3

EXPERIMENTS 1 AND 2

> The whole set [of concepts] is probably retrieved whenever the word is heard.
>
> Miller (1978, p. 99)

Some of the most compelling evidence that multiple meanings of a homograph are exhaustively retrieved followed by a selection of one meaning comes from studies that vary the processing time of a homographic primer. A number of studies reviewed above demonstrated that facilitation obtains for both contextually-congruous and -incongruous associated targets if the SOA is short (less than 300 msec), whereas facilitation obtains for only contextually-congruous associates if the SOA is long. Furthermore, Onifer and Swinney (1981) reported that facilitation at short SOAs obtains for both subordinate and dominant associates, from which they argued that meaning dominance is not a factor in access, but only selection.

One goal of the Experiments 1 and 2 was to replicate Onifer and Swinney's result as a further test of the hypothesis that dominance is a factor only late in the processing of a homograph. The procedure for both Experiments 1 and 2 included visual presentation of single, homographic primers followed by targets that were either subordinate associates (e.g., BOWL - alley), dominant associates (e.g., BOWL - cereal), or unrelated words (e.g., BOWL - oars). The time from onset of the homograph to onset of the target (SOA) was either short (184- and 284-msec SOAs) or long (901-msec SOA), and time to pronounce the target word was the dependent measure. If dominance exerts its effect late in homograph processing, then facilitation of response times should occur for both subordinate and dominant associates using a short SOA, but for only dominant associates using a long SOA.

A second goal of the experiments was to examine the relationship between processes inferred on the basis of pronunciation times and subsequent memory for the primer/target pair members. Balota (1983) argued that automatic access to information in lexical memory does not influence the likelihood that an episodic trace of an event will be formed. If Balota is correct, then facilitation of responses to both subordinate and dominant associates at a short SOA should not result in equal memory for the two kinds of trials. Memory would be expected to be better for members of dominant pairings because there is a bias to remember dominant, rather than subordinate, meanings of homographs (Winograd & Conn, 1970). A long SOA, on the other hand, should most clearly favour memory for members of dominant pairings because the dominant meaning will have been selected and subordinate associates will have been treated as unrelated words.

Balota's view can be contrasted with a recent hypothesis by Koriat (1981) that facilitation at short SOAs is the result of the target selectively facilitating ("backward" priming) one meaning of the homographic primer (see also Seidenberg et al., 1982). Koriat argued that if two stimuli are presented closely in time, the processing of one can be facilitated by the processing of the other, because processing proceeds interactively or in parallel (see also Kiger & Glass, 1983). Applying this view to the recent results of studies with homographs, he contended that facilitation at short SOAs may not reflect access to <u>all</u> meanings of a homograph; rather, the associated target, which is temporally-contiguous with the homograph, may interact with the homograph to select only the meaning specified by it. Koriat's hypothesis has implications for memory for pair members because of the differential control exerted by the target on the homograph at short and long SOAs. At long SOAs, the dominant meaning of a homographic primer should have been selected prior to onset of the associated target; hence, memory for members of dominant pairings should be superior to memory for members of subordinate pairings. At short SOAs, on the other hand, memory should be more determined by the associated target, less by dominance. Thus, an <u>attenuation</u> of the dominance effect from a long to a short SOA would be expected.

Cued recall served as the episodic memory task. After the pronunciation phase, subjects were presented with cue words from that phase (either primers or targets) and were required to recall the corresponding word with which each was paired.

The procedures used in the two experiments were identical, except that different SOAs were used. Experiment 1 used a short SOA of 284 msec and a long SOA of 901 msec, whereas Experiment 2 used two short SOAs: 184 msec and 284 msec. A single Method section serves both experiments.

Method

Subjects

Sixty-four subjects participated in each experiment as part of an introductory course requirement at McMaster University. Conditions were randomly assigned to subjects.

Apparatus

An Apple II computer and an Electrohome monitor (white on grey) were used for stimulus presentation. Both interval and latency timing were accurate to 1 msec. The SOA values are multiples of the screen-refresh rate of the Apple (16.7 msec; see Reed, 1979). Cued recall was a paper and pencil test.

Materials

Ninety-six homographs having at least one noun and one verb meaning were selected from the following published norms: Nelson, McEvoy, Walling, and Wheeler (1980); Kausler and Kollasch (1970); and Wollen, Cox, Coahran, and Kirby (1980). Two criteria can be used to govern the selection of meanings of homographs in terms of dominance. The "total dominance" refers to the proportion of total responses in the norms that can be assigned to the two most dominant meanings. The "dominance ratio" is the ratio of the number of subordinate responses (of the two primary meanings) to the total dominance. A dominance ratio of .50 indicates that, of the proportion of meanings due to the two primary meanings, those two meanings share an equal part. Because the number of homographs nearly exhausted those in the norms, the homographs exhibit somewhat heterogeneous total dominances and dominance ratios. Table 1 presents the number of homographs in each total dominance X dominance ratio category, as well as the number in each cell having either the noun or verb meaning as dominant.

For each homograph, an associate was selected for each meaning, typically the most frequent in the norms. In a small number of cases, the same nominal associate occurred for more than one homograph, so other words appearing as responses in the norms, or obviously-related words not appearing in the norms, were selected from a dictionary or thesaurus.

The experimental lists were constructed as follows. The 96 homographs were divided into 8 blocks of 12 such that the mean frequency and word-length of the dominant and subordinate associates of each homograph in each blocks were approximately equal. There were 8 conditions in the experiment resulting from the factorial combination of 2 levels of relatedness (related and unrelated), 2 levels of dominance (dominant and subordinate), and 2 levels of SOA (284 and 901 msec for Experiment 1; 184 and 284 msec for Experiment 2). The conditions of the experiments were then cycled through blocks so that each block was assigned to each of 8 conditions, resulting in complete counterbalancing of items and conditions.

Table 1

The number of homographs used in the experiments in each of 5 Total dominance X 4 Dominance ratio X 2 grammatical class categories. N and V refer to the number of homographs with either the noun (N) or verb (V) meaning as dominant.

	Dominance Ratio								
	.40 -.49		.30 -.39		.20 -.29		.10 -.19		
Total Dominance	N	V	N	V	N	V	N	V	Total
.90 -.99	4	5	3	2	4	5	5	5	33
.80 -.89	9	4	4	3	4	2	2	1	29
.70 -.79		1	1		3	1	2	2	10
.60 -.69	1	1	4		2	3	2		13
.50 -.59		1	2	3	3	2			11
Total	14	12	14	8	16	13	11	8	96

The construction of the different pair types in the experiment proceeded as follows. If a block was assigned to the related, dominant condition, the homographs in that block were paired with their dominant associates. If a block was assigned to the related, subordinate condition, the homographs in that block were paired with their subordinate associates. If a block was assigned to an unrelated condition, the same procedure was followed as for the related conditions, and then unrelated pairs were created by simply randomly re-pairing homographs and associates within that block. Therefore, for the unrelated, "dominant" condition, re-pairing was between homographs and dominant associates within that block, and for the unrelated, "subordinate" condition, re-pairing was between homographs and subordinate associates within that block. This procedure ensured that latency estimates for dominant and subordinate associates in the related pairs were compared to estimates based on the same nominal targets in unrelated pairs. Table 2 provides examples, and Appendix A lists the homographs and associates by block.

For cued recall, 6 of the 12 pairs in each block were assigned to a condition in which a homograph was a recall cue for an associate, and 6 to a condition in which an associate was a recall cue for a homograph (the "cue type" variable), counterbalanced within blocks and between subjects.

Design

Homographic primers were paired with related target words or unrelated target words, comprising two levels of relatedness. Targets were either subordinate or dominant associates of homographic primers, comprising two levels of meaning dominance. The SOA was either 284 or 901 msec in Experiment 1, and either 184 or 284 msec in Experiment 2, comprising two levels of SOA for each experiment. Therefore, the design for the pronunciation task was a 2 relatedness (related and unrelated) X 2 dominance (dominant and subordinate) X 2 SOA (284 and 901 msec for Experiment 1, and 184 and 284 msec for Experiment 2) repeated-measures factorial. Cell estimates of response time were based on

Table 2

Examples of trial types in Experiments 1 and 2.

	Dominance of Associate			
	Subordinate		Dominant	
Relatedness	Homograph	Associate	Homograph	Associate
Related	refrain bowl train	song pins teach	refrain bowl train	cease cereal tracks
Unrelated	refrain bowl train	pins teach song	refrain bowl train	cereal tracks cease

twelve measures per subject per condition.

The design for cued recall was a 2 relatedness X 2 dominance X 2 SOA X 2 cue type (prime or target) repeated-measures factorial. Cell scores were based on a possible six correct responses.

Procedure

Subjects were tested individually in a sound-attenuated room. Subjects was given instructions for the pronunciation task, and informed that they would receive a paper and pencil cued-recall test after the pronunciation trials. They were encouraged to pay attention to the briefly-presented prime in addition to naming the target rapidly and accurately. Subjects were seated approximately 64 cm. from the monitor

Thirty practice trials, twenty of which were related pairs, preceded the experimental trials. Ninety-six experimental trials were then presented and response times from onset of the target were measured by the computer. Lists were randomized independently for each subject, with the constraint that any one of the 8 conditions could not be presented more than 3 times in succession.

Each trial began with a warning stimulus at the centre of the screen, composed of two bar-markers, 5 cm. apart. The warning stimulus was presented with a 1 sec on-time, followed by a 1 sec blank interval. The primer was then presented between the bar-markers, remaining on the screen for 100 msec and followed by a blank interval of a duration required to sum to the SOA. Then the target was presented, remaining on the screen until the subject responded, which initiated a 3 sec inter-trial interval. All words were presented in upper-case.

Results

Because somewhat independent questions were asked about pronounciation latencies and cued recall, the results for pronunciation for both experiments are presented first, followed by cued recall for both experiments.

Response times

Experiment 1. All trials in which errors occurred (0.7%), including mispronunciation of the target and failure to trip the voice-activated relay, were eliminated from the analysis. In each of the two experiments, mean response times for each condition were based on the cell medians. The rejection level for all comparisons was set at alpha < .05.

The mean response times for conditions, and the difference between related and unrelated conditions, are presented in Table 3. A 2 (relatedness) X 2 (dominance) X 2 (SOA) analysis of variance indicated that related targets were pronounced more rapidly than unrelated targets (541 vs. 550 msec), $F(1,63) = 13.45$, $MS_e = 644.80$; dominant associates were pronounced faster than subordinate associates (542 vs. 550 msec), $F(1,63) = 12.54$, $MS_e = 648.48$;

and responses were faster at 901-msec SOA than 284-msec SOA (533 vs. 558 msec), $F(1,63) = 61.71$, $MS_e = 1317.48$.

The effect of relatedness interacted with dominance, $F(1,63) = 11.88$, $MS_e = 290.48$. Simple main effects analysis indicated that facilitation obtained for dominant associates (549 and 535 msec, unrelated and related conditions, respectively), $F(1,441) = 9.37$, $MS_{e(res)} = 668.96$, but not for subordinate associates (551 and 548 msec, unrelated and related pairs, respectively; $F < 1.0$). Also, within the related conditions, dominant associates were pronounced faster than subordinate associates (535 vs. 548, respectively), $F(1,441) = 8.08$, $MS_{e(res)} = 668.96$.

Examination of the difference scores clearly indicates that some facilitation obtained for subordinate

Table 3

Mean latencies (msec) to pronounce target words, and the difference between unrelated and related conditions, in Experiment 1. SOA = Stimulus-onset asynchrony; Sub. = subordinate associate; Dom. = dominant associate.

SOA (msec)	284		901	
Dominance of Target	Sub.	Dom.	Sub.	Dom.
Unrelated	567	561	536	537
Related	558	548	538	522
Diff.	9	13	-2	15

associates at the short SOA, but not the long SOA, however, the critical three-way interaction of relatedness, dominance, and SOA did not reach significance, $\underline{F}(1,63) = 3.06$, $\underline{MS}_e =$ 466.00, $\underline{p} < .09$.

The results of Experiment 1 are consistent with the hypothesis that the dominant meaning is selected in the absence of context if sufficient processing time on the homograph is allowed (901-msec SOA). However, despite a promising trend, equal facilitation for each level of dominance was not observed at a 284-msec SOA. On the assumption that the short SOA still allowed too much processing time on the homograph, Experiment 2 included a shorter SOA of 184 msec, and repeated the 284-msec SOA. Given the original hypothesis, facilitation was predicted for both subordinate and dominant conditions at both SOAs.

Experiment 2. All trials in which errors occurred (1%), including mispronunciation of the target and failure to trip the voice-activated relay, were eliminated from the analysis. Mean times to pronounce associates and the difference between unrelated and related conditions are presented in Table 4.

A 2 (relatedness) X 2 (dominance) X 2 (SOA) repeated-measures analysis of variance on cell medians confirmed the hypothesis. There was a main effect of relatedness (555 vs. 545 msec, unrelated and related conditions, respectively), $\underline{F}(1,63) = 12.22$, $\underline{MS}_e = 1020.30$, and the dominance manipulation produced no effect, either alone or in combination with other variables. The only other reliable effect in the experiment was a large main effect of SOA, $F(1,63) = 159.06$, $MS_e = 829.77$, such that responses were faster at 284-msec SOA (534 msec) than at 184-msec SOA (566 msec).

In summary, across the two experiments, pronunciation times were consistent with predictions from the two-stage model. Responses to only dominant associates were faciliated using the long SOA (901 msec in Experiment 1), whereas responses to both subordinate and dominant associates were facilitated using SOAs of 184 and 284 msec in Experiment 2.

Table 4

Mean latencies (msec) to pronounce target words, and the difference between unrelated and related conditions, in Experiment 2. SOA = Stimulus-onset asynchrony; Sub. = subordinate associate; Dom. = dominant associate.

SOA (msec)	184		284	
Dominance of Target	Sub.	Dom.	Sub.	Dom.
Unrelated	577	567	539	537
Related	560	560	531	529
Diff.	17	7	8	8

<u>Cued recall</u>

The interest in the episodic measure was whether the facilitation of responses in both subordinate and dominant conditions at the short SOAs would be associated with equal recall of subordinate and dominant pair members. On Koriat's (1981) hypothesis that facilitation reflects selection of the meaning specified by the temporally-contiguous target, there should be an advantage in recall of members of dominant pairs using a long SOA, but this advantage should be attenuated or eliminated at a short SOA. The two-stage, exhaustive access model, on the other hand, posits that facilitation using a short SOA reflects access to all meanings, not selection of one. Therefore, an advantage in recall of dominant pair members should be observed at both SOAs. That is, at the short SOA, the bias to recall the dominant meaning should dominate if no episodic information is available, and at the long SOA, the dominant meaning will have been selected.

<u>Experiment 1</u>. Analysis of variance was performed on the proportion of items recalled out of a possible six correct responses in each cell of the design. Separate analyses were conducted on related and unrelated pairs. Because recall of items from unrelated pairs was uniformly low and no results of interest emerged, only brief mention of these will be made after presenting results for the related pairs. The proportions of associates and homographs correctly recalled given the pair member as a cue, and the

difference between subordinate and dominant related conditions, are presented in Table 5.

A 2 (dominance) X 2 (SOA) X 2 (cue type) analysis of variance indicated a single reliable effect: Recall was consistently greater for members of dominant pairings than for members of subordinate pairings, $F(1,63) = 35.24$, $MS_e = 0.049$. Although examination of Table 5 reveals that there is some attenuation of the effect of dominance from 901-msec SOA to 284-msec SOA if the homograph was the cue (.18 vs. .08, respectively), both the two-way interaction of dominance and SOA and the three-way interaction of dominance, SOA, and cue type did not reach significance, $F(1,63) = 2.80$ and 2.60, $MS_e = 0.034$ and 0.027, $ps < .11$, respectively. All other Fs < 1.0.

Experiment 2. The same analytical procedures were followed as in Experiment 1. The results for cued recall are presented in Table 6. Repeated-measures analysis of variance, with dominance, SOA, and cue type as factors, showed that recall of items in the dominant condition was greater than in the subordinate condition (.38 vs. .27, respectively), $F(1,63) = 34.84$, $MS_e = 0.046$, and recall of associates given the homograph as a cue was greater then recall of homographs given the associate as a cue (.35 vs. .30, respectively), $F(1,63) = 6.08$, $MS_e = 0.039$.

Each of these main effects also entered into an

Table 5

Mean proportions of associated primers (ASSOC) and homographic targets (HOMOG) correctly recalled from the pronunciation phase, given the pair member as a cue, for conditions in Experiment 1. SOA = Stimulus-onset asynchrony; Diff. = Difference between recall in dominant and subordinate related conditions.

			Pair Type in Pronunciation			
			UNREL'D	RELATED		
SOA	cue	TARGET		Subordinate	Dominant	Diff.
284	homog	ASSOC	.05	.23	.31	.08
	assoc	HOMOG	.08	.21	.31	.10
901	homog	ASSOC	.07	.20	.38	.18
	assoc	HOMOG	.06	.24	.35	.11

Table 6

Proportions correctly recalled in Experiment 2.

			Pair Type in Pronunciation			
			UNREL'D	RELATED		
SOA	cue	TARGET		Subordinate	Dominant	Diff.
184	homog	ASSOC	.04	.26	.38	.12
	assoc	HOMOG	.05	.29	.35	.06
284	homog	ASSOC	.06	.28	.46	.18
	assoc	HOMOG	.05	.24	.33	.09

interaction. A dominance X cue type interaction, $F(1,63) = 5.00$, $MS_e = 0.034$, indicated that, although the advantage for dominant pairings was maintained across cue type (.42 vs. .27 for a homograph cue, and .34 vs. .26 for associated cues, respectively), $Fs(1,441) = 20$ and 4.99, $MS_{e(res)} = 0.036$, homographs were better cues than associates for dominant pairings (.42 vs. .34), $F(1,441) = 5.68$, $MS_{e(res)} = 0.036$, but not for subordinate pairings (.27 vs. .26), $F < 1.0$. In short, homographs were especially good cues for their dominant associates. An SOA X cue type interaction, $F(1,63) = 10.12$, $MS_e = 0.025$, indicated that a homograph was a better cue for recalling associates than associates for recalling a homograph at 284-msec SOA (.37 vs. .28), $F(1,441) = 6.42$, $MS_{e(res)} = 0.036$, but not at 184-msec SOA (.32 vs. .32). This clearly reflects the poorer episodic representation of the homographic primer at a short SOA than at a long SOA.

Only brief mention will be made of unrelated pairs. The mean proportions correctly recalled are presented in Tables 5 and 6. Unrelated pairs were analyzed by collapsing over the nominal dominance variable, leaving SOA and cue type as factors in a repeated-measures analysis. In Experiment 1, the only reliable effect in the analysis was that targets were better cues for primers then primers for targets at 284-msec SOA, not at 901-msec SOA. This was indicated by an interaction of SOA and cue type, $F(1,63) = 5.20$, $MS_e = 0.005$, and a significant effect of cue type only at 284-msec SOA, $\underline{F}(1,189) = 5.76$, $\underline{MS}_{e(res)} = 0.005$. This effect seems entirely attributable to the difference in the relative length of the two SOAs in the first experiment, rather than the shortness of SOA per se, because in Experiment 2 in which both SOAs were short, there was no effect of any variable (all $\underline{F}$s < 1.0).

Discussion

The results of Experiments 1 and 2 can be summarized by considering both response times and recall together, first for the long SOA (901 msec), and then for the short SOAs (184- and 284-msec SOA).

Long SOA. In the long-SOA condition (901 msec) pronounciation was speeded only for dominant associates, and cued recall of members of dominant pairings was greater than recall for subordinate pairings. These data are consistent with the observation reported in other experiments that if no context precedes the homograph, the semantic ambiguity is resolved in terms of the dominant meaning. The response-time results replicate Simpson (1981), and the memory results replicate Winograd and Conn (1971), both of whom used different procedures.

Short SOAs. At the short SOAs (Experiment 2; and to some extent, 284-msec SOA in Experiment 1), pronunciation of both dominant and subordinate associates was speeded relative to the unrelated baseline. This result therefore replicates Onifer and Swinney (1981) and is consistent with their view that dominance plays a role relatively late in the disambiguation process. Furthermore, despite comparable facilitation in the pronunciation task for dominant and subordinate associates, there was still an advantage in recall of members of dominant pairs. The result is therefore consistent with Balota's (1983) notion that "automatic" priming is the result of accessing, not selective, operations. However, Koriat's (1981) hypothesis is not entirely ruled out because there was an unreliable, but not trivial, trend in both experiments for the advantage in recall of dominant associates (given a homograph as a cue) to be attenuated at the shorter SOA. Some selective influence may be at work at short SOAs, an issue addressed further in Chapter 5.

Chapter 4

EXPERIMENTS 3 AND 4

> There is excellent evidence that subjects cannot always choose to avoid processing aspects of an input item that they desire to ignore.
>
> Posner (1978, p. 91)

Most priming experiments that have provided evidence consistent with exhaustive access have used a homograph as a primer to which no overt response is made. As such, the temporal dynamics of ambiguity resolution can be studied by varying the processing time of the homograph before some response is made to a target stimulus. The logic of varying the processing time of a homographic primer is based on the distinction between operations that access memorial information and those that select from some larger accessed set. Because access and selection are hypothesized to take place sequentially, over time, the source of priming effects of a homograph on other stimuli will vary according too "how far along" processing of the homograph has proceeded: If a target word is presented very early in the processing of a homograph, facilitation of responses to associated words must result from the activation of meanings entailed by access; if a target word is presented relatively late in the processing of a homograph, selection has been given time to occur and facilitation of responses to associates will occur only for a selected meaning.

The same logic cannot be applied if response time to the homograph itself is used to make inferences about retrieval processes, because the processing time of the homograph cannot be controlled and a person's overt response entails that selection of a meaning has already occurred; one does not recognize and overtly respond to a homograph unless a meaning has been determined. Hence, the problem with using a homographic target for making inferences about accessing operations is that there is no possibility of controlling the point at which one "samples" from it in the course of its processing; its processing is under the control of the subject, and a response entails that the accessing operation of interest has already occurred. If a homograph is to be used as a target to make inferences about exhaustive access, evidence must be found that multiple meanings have been accessed in the course of selecting one of those meanings. Experiments 3 and 4 addressed this issue.

Before developing the rationale for the present experiments, three preliminary lines of evidence from studies using homographic targets are relevant. In brief, the first line of evidence (Rubenstein, Garfield, & Millikan, 1970; Jastrezembski, 1981) shows that the time to respond to words is sensitive to multiplicity of meaning. The second line of evidence (Balota, 1983) shows that a word primer associated with either of two meanings of a symmetrical homograph (e.g., fence - yard and inch - yard) can facilitate response times to the homograph if the SOA is either short or long. The third line of evidence (Carpenter & Daneman, 1981) shows that there is a powerful bias to select the dominant meaning of an asymmetrical homograph, even if it is preceded by a context biasing a subordinate sense. Consider each of these in turn.

The first line of evidence shows that multiplicity of meaning is a potent variable for influencing the speed of recognition of words. The rationale here is that multiple lexical entries should provide an advantage in speed of recognition over a single lexical entry because of a higher probability of finding one of many meanings than only a single meaning. For example, Rubenstein, Garfield, and Millikan (1970) and Jastrezembski (1981) had subjects make lexical decisions about letter-strings, and the word letter-strings were either homographs or non-homographs. They found that homographs were responded to more rapidly than non-homographs. The effect of homography was not trivial because the advantage conferred by multiplicity of meaning was substantially greater than that conferred by word frequency. Clearly, number of meanings has some bearing on lexical access.

However, the different models of access under consideration can each account for the effect of homography, so no discrimination among them is possible given these data. This follows from the fact that, in general, there is a higher probability of one recognition criterion of many being reached than of only one being reached, whether the criterion is "first to reach a threshold" (as in the logogen, exhaustive-access model), or "first to be found in a search" (as in ordered or selective access). The explanation of the advantage for homographs given by Rubenstein et al. (1970) and Jastrezembski (1981) invoked exhaustive access, based on Morton's (1969, 1979) logogen model. Specifically, Jastrezembski (1981) hypothesized that recognition of a word with more than one meaning includes parallel activation of separate word detectors or logogens corresponding to each meaning. The first logogen of the activated set to exceed some threshold determines the meaning that is assigned. Homographs are recognized more rapidly than non-homographs because there is a higher probability that one of many activated logogens will exceed threshold within a give time, than that only one logogen will exceed threshold within the same time. Other models that do not posit retrieval of multiple entries can also accomodate the advantage in speed of recognition for homographs. Given selective access, memory could be randomly searched for a meaning until at least one was located, with a higher probability of finding one of many meanings than finding only a single meaning. Or, given ordered-access, a search of lexical memory could continue until at least one meaning was located, at which point the search would terminate; the advantage for homography would consist in a higher probability of locating one of many lexical entries within a given time than locating only one in the same time. However, ordered access would predict an advantage for homography only if two or more meanings were equi-probable; for meanings of differing frequency, an ordering of search would dictate that only a single meaning, the most frequent, would be accessed. The only conclusion of interest from single-word studies of homography is that multiplicity of meaning systematically affects recognition time; the alternative models are otherwise underdetermined by the results.

The second preliminary line of evidence demonstrates that time to respond to symmetrical homographs is facilitated by an associated primer related to <u>either</u> of the equi-dominant meanings. Furthermore, this facilitation obtains if the processing time for the associated primer is either extremely short or relatively long. The import of these findings will be clear presently. The relevant study is by Balota (1983), discussed in Chapter 2. Balota employed speeded lexical decision in which target words were symmetrical homographs. Primers preceded the target stimuli, and were either words associated with one of the two meanings, unrelated words, or neutral stimuli (XXXXX). The primers were presented under two temporal conditions: either for a long duration, such that subjects could easily report them, or for an extremely short duration and pattern masked, such that subjects could not reliably report the presence of a stimulus. The interesting result was that responses to homographs were speeded (compared to an unrelated or neutral baseline) by the prior presentation of an associate of either of two meanings in both the short and long presentation conditions. However, because symmetrical homographs were employed, the results are consistent with selective, ordered, or exhaustive access. If access were selective, priming would still occur on half the trials, conferring an average speed advantage to homographs preceded by associates. The same rationale would hold for ordered access because one of two equi-dominant meanings would be accessed and compared with the context half the time on average. The result is easily explicable in terms of exhaustive access because the spelling pattern itself would provide equal access to two meanings and the primer would boost activation of one of those. The latter alternative is preferable on the basis of Holley-Wilcox and Blank's (1980) demonstration that homographic and non-homographic primers facilitate responses to associates equally (see Chapter 2).

The rationale for the present experiments can now be introduced before considering the third source of evidence from experiments employing homographic targets. The interest in the present experiments was to test the notion that exhaustive access occurs if the homograph is asymmetrical, and to do so by measuring responses to the homograph. The difficulty, as noted in the introductory comments, is that a response to a homograph entails that a meaning has been selected, and that the activation of meanings associated with accessing operations cannot be easily examined. The results of the above experiments illustrate the problem; they are compatible with different views of access.

The rationale for the present procedure is based on the Stroop effect (Dyer, 1973; Jensen & Rohwer, 1966; Stroop, 1935). In the Stroop procedure, a rapid response is required to a target stimulus, and another stimulus that "competes" with that response is presented simultaneously or close in time. The "Stroop effect" refers to an inhibition of response time to the target stimulus caused by the competing stimulus, compared to a neutral or non-competing stimulus. The Stroop effect has been investigated thoroughly using colour words as interfering stimuli and coloured ink as target stimuli (and vice versa). However, critical for present purposes, Warren (1972, 1974) has shown that any stimulus that is highly activated in memory can interfere with colour naming.

Warren's notion has been applied to the processing of homographs by Conrad (1974) and Oden and Spira (1983). Their technique included presenting subjects with homographs as priming stimuli (sometimes preceded by biasing sentence fragments), and measuring the time to name the colour of ink in which associates of the homographs were printed. They hypothesized that the time taken to name an ink colour would reflect the level of activation of the various meanings of the homograph, and that highly activated meanings would entail colour-naming interference from associates of those meanings. The basic finding was that latencies to name the ink-colour of associates of either of two meanings of a homograph were slowed relative to an unrelated baseline, and this was taken as evidence that multiple meanings of the homograph must have been activated.

The application of Stroop interference in the present experiments is quite straightforward. If both subordinate and dominant meanings of a homograph are initially accessed in the course of making a response, the level of activation in memory of these meanings should be high, presumably for only a very brief time. If a response to a homograph is based on only <u>one</u> of the activated meanings, then one should be able to interfere with naming the homograph by presenting a word that competes with the selected meaning, that is, by temporarily increasing the activation of the competing meaning.

Returning to the third source of evidence from experiments requiring responses to homographs, there is good evidence of an overwhelming bias to pronounce the <u>dominant</u>

meaning of an asymmetrical homograph. Carpenter and Daneman (1981) demonstrated that for asymmetrical, non-homophonic homographs (e.g., drain - sewer, or tailor - sewer), there is a bias to pronounce these words in accordance with their dominant sense. This selectional bias is difficult to overcome even with a prior context in the form of a sentence biasing the subordinate meaning. Radical asymmetry makes it almost impossible to avoid a garden path in which the dominant meaning is first inappropriately selected, after which recovery heuristics are used to make semantic sense of the whole utterance. A context can bias selection if the homographs are not strongly asymmetrical, because context and dominance "trade off" against one another to determine which meaning is selected.

In light of the evidence that the dominant meaning of a homographic target is selected, and assuming that subordinate meanings are activated in the course of its selection, then a subordinate associate should be a potentially interfering stimulus. Importantly, in order for interference to occur, the interfering stimulus would need to be presented just such that it competes with pronunciation of the homograph in its dominant sense. It has been demonstrated that Stroop interference is limited to a relatively narrow temporal window (Dyer, 1971; Flowers, 1975; see also, Dyer & Severance, 1972; Gumenik & Glass, 1970). If the competing stimulus is sufficiently separated in time from the target, interference with colour naming is attenuated. Therefore, the subordinate associate would need to be in close temporal proximity to the homographic target. Pilot work indicated that using a subordinate associate as a primer with an SOA of between 184 and 284 msec captured some of this critical interval, ensuring the required "processing overlap" between the interfering stimulus and the homograph.

In the critical condition of the experiments, homographic targets were preceded by a subordinate associate using a short SOA. The hypothesis was that there would be naming interference in this condition. Various other control conditions were included to assess the hypothesis. A "no-interference" baseline included a primer that was unrelated to the homograph. An unrelated word should not compete with responding to a homograph because it is semantically unrelated to the information accessed in the course of processing the homograph itself. There was also a condition of response <u>facilitation</u>, such that responses to the homograph would not be hindered, but helped. If the dominant meaning is selected, a dominant associate should facilitate this process; hence, homographs were also preceded by primers that were dominant associates. Whereas subordinate associates should create interference, dominant associates should create facilitation. Finally, if the Stroop-based logic outlined above is correct, particularly with respect to the narrowness of the temporal window in which interference occurs, a long SOA should not result in interference from a subordinate associate; hence, interference should be attenuated from a short to a long SOA. Accordingly, a long SOA (901 msec) was used in the experiments.

What further can be said about the effects of word primers on responses to a homograph at a long SOA? Analagous conditions have been used in other experiments. The long-SOA condition is virtually identical to Balota's (1983) visible-primer condition, except he used symmetrical homographs and a lexical-decision task. Balota found equal facilitation of responses to homographs if preceded by an associate of either meaning. The long-SOA condition is also somewhat similar to the conditions of Carpenter and Daneman's (1981) experiment, except they used sentence contexts, and eye-fixation duration and pronounciation bias as dependent measures. Unlike Balota, Carpenter and Daneman included the dominance variable. They showed that there is a bias to pronounce the dominant meaning of an asymmetrical homograph, and that for radical asymmetry, this bias is hard to overcome even with a strong context. Given the bias to select the dominant meaning, a dominant primer should only enhance this bias, creating a condition of facilitation. What about a subordinate primer? There is only one firm hypothesis given the predicted interference at a short SOA: There should be no interference at the long SOA. Whether there would be facilitation is difficult to predict because, as Carpenter and Daneman (1981) have shown, relative dominance and contextual constraint trade off in determining which meaning of a homograph is pronounced. The asymmetry of the homographs employed in the experiments was certainly not radical, so context might tip the balance in its favour. However, the single-word contexts cannot be considered "strong" either. If it is assumed that dominant and subordinate associates are equally biasing as contexts per se, the subordinate condition should be at somewhat of a disadvantage on the basis of its lower dominance. Context may compensate somewhat for the asymmetry; modest facilitation might be expected with a subordinate primer, but as noted above, there should be no indication of inhibition.

The experiments also included a cued-recall test. As in Experiments 1 and 2, after the pronunciation phase, subjects were presented with a list of cue words from those trials. Cue words were either primers or targets, and the task was to recall the corresponding pair member. Additional evidence was sought in the memory test for the encoding processes assumed to be operating in the pronunciation task. In accordance with the latency predictions for the short and long SOAs, there should be a larger advantage in recall of members of dominant pairings at the short SOA than at the long SOA. The prediction, incidentally, is the opposite of that for Experiments 1 and 2, which used homographic primers. In those experiments, there was a somewhat larger advantage in recall of members of dominant pairings at a long SOA than a short SOA.

In summary, the procedure in the experiments was as follows. Homographs were presented as target stimuli requiring rapid pronunciation. On each trial, a homograph was preceded by a single word primer that was either a subordinate associate, a dominant associate, or an unrelated word. In each experiment, the SOA was either short or long (184 and 901 msec for Experiment 3; 284 and 901 msec for Experiment 4). The dependent variable was time to pronounce the homograph from its onset. After the pronunciation trials, subjects were given a test of cued recall in which either a homographic primer was a cue for recalling an associated (or unrelated) target, or an associated (or unrelated) target was a cue for recalling a homographic primer.

A general Method section will suffice for both Experiments 3 and 4, which were identical except for changing the short SOA in Experiment 4.

Method

Subjects

Subjects participated in the experiments as part of a course requirement for introductory psychology at McMaster

University. Experiment 3 included 32 subjects and Experiment 4, 64 subjects. Conditions were randomly assigned to subjects.

Apparatus and Materials

The apparatus and the 96 homographs used in the first experiments were used. New associates were selected for each meaning of the homographs (Kausler & Kollasch, 1970; Nelson, McEvoy, Walling, & Wheeler, 1980; Wollen, Cox, Coahran, & Kirby, 1980). The homographs and subordinate and dominant associates are presented in Appendix B.

List construction was accomplished by first dividing the 96 homographs into 8 blocks of 12 homographs such that the mean frequency and word length of the homographs in each block were equated. There were 8 conditions in each experiment resulting from the factorial combination of 2 levels relatedness (related and unrelated), 2 of dominance (dominant and subordinate), and 2 of SOA (184 and 901 msec in Experiment 3, and 284 and 901 msec in Experiment 4). Each block of 12 homographs was assigned to each of the eight conditions in the experiment, creating four different experimental lists (two relatedness X two dominance), which, when assigned to one of two SOAs, yeilded eight unique presentations, representing complete counterbalancing of conditions and items. In each experiment, an equal number of subjects were assigned to each of the presentations.

If a block was assigned to the related, dominant condition, dominant associates were selected as primers for those homographs, and if a block was assigned to the related, subordinate condition, subordinate associates were selected as primers for those homographs. If a block was assigned to an unrelated condition, subordinate and dominant associates were selected just as they were for the corresponding related condition, but unrelated pairs were created by randomly re-pairing associates with different, unrelated homographs within the same block. Thus, the unrelated, "dominant" condition was composed of dominant associates re-paired with different homographs within the same block, and the unrelated, "subordinate" condition was composed of subordinate associates re-paired with different homographs within the same block. This procedure ensured that estimates of response time for related conditions and their unrelated control conditions were based on the same nominal target items.

For cued recall, half of the primer-target pairs in each block of 12 were assigned to a condition in which primers were cues for recalling targets, and half to a condition in which targets were cues for recalling primers. These assignments were counterbalanced within blocks and between subjects. There were six possible correct responses in each cell of the recall design.

Procedure

Subjects were tested individually in a sound-attenuated room. Subjects were given instructions for the pronunciation task, were informed that they would receive a paper and pencil cued-recall test after the pronunciation trials, and were encouraged to also pay attention to the briefly-presented prime in addition to naming the target. Subjects were seated at a 64 cm. viewing distance from the stimuli.

Thirty practice trials, twenty of which were related pairs, preceded the experimental trials. Ninety-six experimental trials were then presented and response times from onset of the target were recorded by the computer. Lists were randomized independently for each subject, with the constraint that any one of the eight conditions could not be presented more than three times in succession.

Each trial began with a warning stimulus at the centre of the screen, composed of two bar-markers, 5 cm. apart. The warning stimulus was presented with a 1 sec on-time, followed by a 1 sec blank interval. The primer was then presented between the bar-markers, remaining on the screen for 100 msec and followed by a blank interval of the required duration to sum to the SOA. Then the homographic target was presented, remaining on the screen until the subject responded, initiating a 3 sec inter-trial interval. All words were presented in upper-case.

Results

The response times for the pronunciation task for Experiments 3 and 4 will be discussed together, followed by cued recall for both experiments.

Response times

Experiment 3. Errors resulting from mispronunciation or failure to trip the voice-active relay (1.28%) were eliminated from the analysis, and alpha < .05 was considered significant. Analyses were conducted on the median response times of each subject-cell. Mean response times and the difference between related and unrelated conditions are presented in Table 7.

Repeated-measures analysis of variance, with relatedness (unrelated and related), dominance (dominant and

Table 7

Mean times (msec) to pronounce homographic targets, and differences (Diff.) between the related and unrelated conditions, for Experiment 3. Sub. = Subordinate; Dom. = Dominant; SOA = Stimulus-onset asynchrony.

SOA (msec)	184		901	
Dominance of primer	Sub.	Dom.	Sub.	Dom.
Unrelated	541	545	473	475
Related	540	535	466	470
Diff.	1	10	7	5

subordinate), and SOA (184 and 901 msec) as factors, showed only a single marginal effect of relatedness ($p > .07$).

Experiment 4. Experiment 4 repeated the procedure, except for substituting an SOA of 284 msec instead of 184 msec, and doubled the number of subjects ($N = 64$) to provide more statistical power. The priming effects in Experiment 3 were small, and it was thought justified to use a more powerful *a priori* multiple comparison procedure.

Pronunciation errors and those due to failure to trip the voice-activated relay (1.43%) were eliminated from the analysis. The results are presented in Table 8.

Inspection of the difference scores shows that the results were generally consistent with expectation. One-tailed t-tests ($t_{crit}(2,438) = 1.65$, $MS_{e(res)} = 779$, alpha <

Table 8

Mean times (msec) to pronounce homographic targets, and differences (Diff.) between the related and unrelated conditions, for Experiment 4. Sub. = Subordinate; Dom. = Dominant; SOA = Stimulus-onset asynchrony.

SOA (msec)	284		901	
Dominance of primer	Sub.	Dom.	Sub.	Dom.
Unrelated	541	549	497	499
Related	550	535	493	493
Diff.	-9	14	4	6

.05) comparing the difference between the mean of each related condition and its corresponding unrelated control indicated that at 284-msec SOA homographs were pronounced reliably more <u>slowly</u> if preceded by a subordinate associate than an unrelated word (550 vs. 541 msec; t_{obs} = 1.82), and reliably <u>faster</u> if preceded by a dominant associate than an unrelated word (535 vs. 549 msec; t_{obs} = 2.83). At 901-msec SOA homographs were not pronounced differently than baseline, whether preceded by a subordinate or dominant associate (t_{obs} = .81 and 1.21, respectively).

Cued recall

The interest in cued recall was whether episodic memory would show effects parallel to response times. In particular, a larger effect of dominance was expected at the short SOAs than the long SOA. Analyses of variance were performed on the proportion of items correctly recalled out of a possible six correct responses, separately for unrelated and related pairs. Because recall of items from unrelated pairs was low and no effects of interest emerged, only brief mention will be made of these pairs.

<u>Experiment 3</u>. Proportions correctly recalled for conditions, including the differences between subordinate and dominant conditions for related pairs, are presented in Table 9.

For unrelated pairs, the nominal dominance variable was collapsed over, leaving 2 levels of SOA and 2 levels of cue type. Repeated-measures analysis of variance indicated no differences between the conditions (all F's < 1).

For related pairs, a 2 (dominance) X 2 (SOA) X 2 (cue type) analysis of variance indicated that all three main effects were reliable. Recall was greater for members of dominant (.37) than subordinate (.27) pairs, $F(1,31) = 26.72$, $MS_e = 0.028$; homographs cued by associates were better recalled (.37) than associates cued by homographs (.29), $F(1,47) = 5.16$, $MS_e = 0.039$; and recall was greater at 901-msec SOA (.35) than 184-msec SOA (.29), $F(1,31) = 6.59$, $MS_e = 0.033$. No interactions were significant (all Fs < 1.0).

Table 9

Mean proportions of associated primers (ASSOC) and homographic targets (HOMOG) correctly recalled from the pronunciation phase, given the pair member as a cue, for conditions in Experiment 3. SOA = Stimulus-onset asynchrony; Diff. = Difference between recall for dominant and subordinate related conditions.

			Pair Type in Pronunciation			
			UNREL'D	RELATED		
SOA	cue	TARGET		Subordinate	Dominant	Diff.
184	homog	ASSOC	.06	.27	.36	.09
	assoc	HOMOG	.07	.20	.33	.13
901	homog	ASSOC	.08	.33	.43	.10
	assoc	HOMOG	.07	.27	.37	.10

Experiment 4. The mean proportions correctly recalled for conditions in Experiment 4 are presented in Table 10. A 2 (SOA) X 2 (cue type) repeated-measures analysis of variance for unrelated pairs indicated only that targets cued by primers were better recalled than primers cued by targets, $F(1,63) = 4.29$, $MS_e = 0.005$.

For related pairs, a repeated-measures analysis of variance, with dominance, SOA, and cue type as variables, revealed that recall of members of dominant pairs (.38) was greater than of subordinate pairs (.27), $F(1,63) = 43.74$, $MS_e = 0.033$, and recall of homographs cued by associates (.36) was

Table 10

Mean proportions of associated primers (ASSOC) and homographic targets (HOMOG) correctly recalled from the pronunciation phase, given the pair member as a cue, for conditions in Experiment 4. SOA = Stimulus-onset asynchrony; Diff. = Difference between recall for dominant and subordinate related conditions.

			Pair Type in Pronunciation			
			UNREL'D	RELATED		
SOA	cue	TARGET		Subordinate	Dominant	Diff.
284	homog	ASSOC	.07	.29	.41	.12
	assoc	HOMOG	.06	.22	.34	.11
901	homog	ASSOC	.09	.33	.42	.09
	assoc	HOMOG	.06	.27	.36	.08

greater than recall of associates cued by homographs (.30), $\underline{F}(1,63) = 12.59$, $\underline{MS}_e = 0.044$. Apart from marginally better recall at 901-msec SOA than 284-msec SOA ($\underline{p} < .08$), no other effects were significant (all $\underline{F}$'s > 1.0).

In summary, across the two experiments, there was no indication in cued recall of an attenuation of the dominance effect from a short SOA to a long SOA, despite evidence from pronunciation times of different processing at the different SOAs. It may be that effects in response time were simply too small to show up in cued recall.

Discussion

It was predicted that if both subordinate and dominant meanings of a homograph are accessed, given the normal bias to pronounce the dominant meaning of an asymmetrical homograph, one should be able to interfere with the speed of its pronunciation by presenting a subordinate associate in close temporal proximity. This prediction was confirmed in Experiment 4 at the short SOA: Responses to homographs primed by subordinate associates were inhibited. On the other hand, a dominant associate should have a facilitative effect on response times because it is congruous with the preferred pronunciation, a prediction that was also confirmed in Experiment 4 at the short SOA. It was also found, as expected, that inhibition from a subordinate associate was restricted to a short SOA. At the long SOA of

901 msec, responses to homographs primed by a subordinate associate were not inhibited, but were non-significantly facilitated, as were responses to homographs primed by a dominant associate. The only deviation from expectation was that no facilitation obtained for the dominant condition at the long SOA, which would have been predicted on the basis of other experiments (Balota, 1983; Carpenter & Daneman, 1981). It was uncertain as to whether facilitation would obtain for the subordinate condition at the long SOA, so expectation was not violated, but given that the dominant condition did not show facilitation either, it is not clear how to interpret the long-SOA results. Because all effects on response time in the experiments were small, real facilitation at a long SOA may have simply gone undetected. It should also be remembered that the primers were free-associative <u>responses</u> to homographs taken from the homograph norms, so that the direction of association between the primer and target was actually <u>backward</u>. This would not be a problem for the short-SOA condition assuming concurrent processing of the associate and homograph. At the long SOA, on the other hand, subjects would have completed their processing of the associate prior to onset of the homograph, and facilitation would have had to be based on an expectancy or attentional strategy (Neely, 1977). The homograph, however, would be unlikely to be included in an expectancy-based set of words related to the associate.

The results at the short SOA have implications for Koriat's (1981) view that in the homograph-associate order of presentation (e.g., Experiments 1 and 2), the associated target may have a selective effect on the processing of the homographic primer. On this view, the short-SOA condition should have resulted in facilitation in both the subordinate and dominant conditions, which was clearly disconfirmed.

Can other models of homograph processing explain the results? Both the inhibition for the subordinate condition at the short SOA and the lack of inhibition at the long SOA must be accounted for. An account based on ordered search could certainly handle greater facilitation for the dominant condition at a short SOA, but inhibition for the subordinate condition would be problematic. Inhibition at a short SOA should only occur if there is competing activation, but on the basis of ordered search, subordinate meanings would remain unaccessed if the dominant meaning were selected. Because the results at the long SOA were ambiguous for independent reasons, no proper appraisal can be made. Selective access would predict facilitation of responses to a homograph primed by a related word (Schvaneveldt, Meyer, & Becker, 1976), but again, the lack of any effects at the long SOA is a problem for all models. At the short SOA, however, the model would have trouble with the results for a reason similar to ordered access: There should be no response competition from non-accessed meanings. In general, selective access has difficulty with interactions over time because it does not distinguish between processes that access the mental lexicon and those that select from it.

As for cued recall, the results were relatively straightforward, again documenting the bias associated with the recall of a homograph's dominant meaning, but they were not informative with regard to encoding processes hypothesized to be operating in the pronunciation task.

In summary, the experiments offer some evidence for exhaustive access directly from responses to homographic targets. The demonstration must nonetheless be considered preliminary until a more systematic examination of the boundaries of the observed phenomenon has been undertaken.

Chapter 5

EXPERIMENTS 5 AND 6

> "...a substantive [word] standing by itself is usually the equivalent of too abstract an idea for us to conceive properly without delay. Thus it is very difficult to get a quick conception of the word 'carriage' because there are so many different kinds - two-wheeled, four-wheeled, open and closed, and in so many different possible positions, that the mind possibly hesitates amidst an obscure sense of many alternations that cannot blend together. But limit the idea to say a landau, and the mental association declares itself more quickly."
>
> Galton (Quoted in James, 1950, p. 556)

If the processing of homographs includes access to multiple meanings regardless of semantic context, some version of what Forster (1981) has called the "autonomy" principle must be defended. The autonomy principle asserts that at least some processes that interrogate the mental lexicon do so independently of the semantic environment of a word. Both ordered search and exhaustive access subscribe to versions of the autonomy principle because context-independent processes are attributed to word recognition. For these models to be sustained, it must be demonstrated that context has no influence on the particular form of memory access they posit. The experiments reported in this chapter re-examined the issue of context with particular reference to exhaustive access. The interest was to find a biasing context sufficiently strong to test the notion that access to a homograph's meanings is invariant over context.

What kinds of contexts have been employed in earlier studies, and with what results? Both single words and sentences (sometimes including associated words) have been used. Of those studies using word primers, Schvaneveldt et al.'s (1976) procedure required lexical decisions about each of three successive letter-strings. On the critical trials, a homograph was preceded by a word biasing one of its meanings, and followed by a word related to an alternate meaning (e.g., river - bank - money). The important result was that no facilitation obtained for the final word, a result consistent with selective access. However, as discussed in the foregoing chapters, if the processing time of the homograph is varied before onset of the target, their result obtains only if a long exposure duration is used; if a short duration is used, the results are consistent with exhaustive access (Marcel, 1980; Maxwell, 1981). Schvaneveldt et al.'s (1976) finding can confidently be attributed to the fact that too much processing time was allowed on the homograph before the final associated target was presented.

Most priming experiments have used sentences to effect a bias, and these too have demonstrated facilitation for associated targets that are contextually incongruous if the processing time for the homograph is brief (Kintsch & Mross, 1985; Onifer & Swinney, 1981; Seidenberg et al., 1982;

Swinney, 1979; Tanenhaus & Seidenberg, 1979). How biasing were the sentences used in these studies? Because the results typically show that context does not have an effect at short SOAs (or ISIs), but does at long SOAs, there is no doubt that the sentences actually did bias the homograph. The question still remains as to whether the bias induced by these sentences was sufficiently strong. Although the sentences may have approximated those encountered in normal reading material, they may not have provided enough constraint to test an hypothesis as extreme as exhaustive access.

The reader can appreciate the kind of weak bias induced by the sentence fragments employed in these experiments by examining each of a number of sentences fragments presented prior to a critical homographic primer by Onifer and Swinney (1981). The remainder of the sentences (not shown) appeared after the homograph. The reader may try to attempt to generate the homograph for the blank. The correct homographs for each blank are below the sentences fragments, with subordinate (-s) and dominant (-d) meanings indicated.

(a) The worker had a large tattoo across his ______

(b) As the barge passed through the ______

(c) Because we were so hot we put a ______

(d) The door was closed with a strong ______

(e) Hamburger is chopped up _______

(f) Her wedding dress had been kept in an old _______

(g) As the performer was leaving the dressing room an admiring _______

(h) The camper used a hammer to drive the metal _______

(a) chest-d (b) lock-s (c) fan-d (d) lock-d
(e) steak-d (f) chest-s (g) fan-s (h) stake-s

These fragments clearly require some time-consuming guesswork about what word fits in the blank. An associated word in the sentence, like <u>tattoo</u> (chest) or <u>hamburger</u> (steak) certainly helps, but the constraint is clearly not strong, although it is probably <u>characteristic</u> of isolated sentences. It is not surprising that Forster (1981) argued, concerning the constraint imposed by sentence contexts, that semantic information in a sentence context does not "prime", in the sense of restrict activation to, a small set of related words that are consistent with the semantics of the sentence. He found that sentence contexts did <u>not</u> facilitate pronunciation of either highly predictable or semantically appropriate, but unpredictable, word completions; rather, inappropriate word-completions were <u>inhibited</u>. In other words, Forster's suggestion is that sentences "rule out" a whole set of completions that are semantically incongruous, but they do not "rule in" a small, specific set of congruous completions. If Forster's results are representative of sentence contexts in general, sentences used in prior studies have not provided optimal bias.

Other criticisms can be made of the experiments employing sentence contexts. For one, the amount of constraint in any one sentence in an experiment is most surely influenced by the "sentential environment" of the whole experiment. Having to switch attention every few seconds from topic to topic introduces an important element of uncertainty into an experiment. Moreover, the sentences have typically been incidental to the main task of making a response to some target. A subject may be listening to a sentence while looking for a visually-presented target. The kind of processing on incidental material is surely not the same as processing on focal material. It may be slower, or less efficient, etc.

The following three criteria were thought important to ensure that a context was strong. First, the bias should semantically specify the exact meaning of a subsequent homograph; the context must "rule in" a single interpretation. This is the only strong test of a contextually invariant mode of access. Second, the amount of bias should be assessible independent of the response times that are used to evaluate lexical access (by an episodic memory test, or the like). Third, the divided attention requirement should be eliminated because it is presumably when attention is focused that resources are most committed to resolving ambiguity.

A study by Holmes (1979, Experiment 5) went some way toward meeting these conditions. He used a sentence comprehension task in which the sentences containing homographs biased a dominant or a subordinate interpretation and the dependent measure was time to comprehend the sentences. In a number of experiments, Holmes had found a consistent advantage in time to comprehend sentences biasing the dominant meaning. In an attempt to eliminate the advantage for the dominant meaning, he presented a sentence containing a synonym of the critical homograph (or a word closely related in meaning) prior to each sentence containing the homograph. For example, the sentence "The lifting machines had been stationed near the truck" was presented prior to "The truck had two cranes beside it"; or the sentence "The wading birds could be observed near the lake" was presented prior to the sentence "The lake had two cranes beside it". The effect of this manipulation was to eliminate the dominance effect. Unfortunately, directional trends in the data still favoured the dominant meaning, leaving the null result inconclusive. Nonetheless, Holme's method of biasing was correctly conceived in that prior, reasonably specific, semantic information about the forthcoming homograph was provided, and the sentence containing the biasing information was presented before the sentence containing the homograph .

The present procedure went further. The actual homographs to be used as primers in a subsequent reaction-time task were first studied in biasing context. Subjects therefore saw and interpreted each homograph before it was used as a primer. This was taken to constitute a strong test of exhaustive access because one should not be able to by-pass, or otherwise interrupt, a contextually invariant process, including having already resolved a homograph's meaning. In effect, the procedure asked the question "Does having already selected a single meaning bias subsequent access?", and in this sense is the converse of Balota's (1981) question, who asked whether accessing a meaning biases subsequent selection.

The procedure of first studying the homograph also has the advantage of setting the interpretation of each homograph independently of the occasion of test, ensuring that subjects do not have to divide their attention between a secondary task (reading or listening to a biasing context) and a primary task (responding to a target). Furthermore, because the experiments included repeating the homograph in a study/test paradigm, contact was made with a large and recent research literature on repetition effects and the relationship between semantic and episodic memory. There is considerable evidence that processing of a stimulus is substantially affected on its second presentation. For example, time to make a lexical decision to a repeated stimulus (Scarborough, Cortese, & Scarborough, 1979) or to pronounce a repeated word (Kirsner and Smith, 1974) is less on the second than on the first presentation, and the probability of perceptual identification of a degraded stimulus is greater after a single prior exposure (Jacoby, 1983). There are such diverse findings as a recency effect of a negative probe-item in immediate memory search (Monsell, 1978), and a response repetition effect in choice reaction time (Rabbitt & Vyas, 1973). The literature on episodic priming (e.g., McKoon & Radcliff, 1979) also demonstrates that the prior presentation of pairs of words can result in considerable advantages in speed of recognition for one member of the pair given the other member as a cue.

More directly relevant to the present experiments is a study of homographs by the present author (Maxwell, Note 1), which showed that first studying a homograph in a context results in significantly more bias when the associate and homograph are subsequently used as primers in a reaction-time task than simply seeing the associate and the homograph as primers for the first time. In the experiment, subjects in a study group were initially required to generate sentences using a homograph and either a dominant or subordinate associate, whereas subjects in a no-study group had no pre-exposure to the homographs. Subsequent reaction time trials included presenting three stimuli sequentially: two primer words and a target word. The first primer was an associate of a homograph, and the second primer was the homograph itself, both of which had been studied earlier by the study group. The target was a new word, either an associate of the homograph congruous in meaning with the first (e.g., hen-chick-egg), (2) an associate incongruous with the first (e.g., hen-chick-girl), or a word unrelated to either primers (e.g., cease-refrain-girl). There was either a short or long processing time for the homograph before onset of the target (200 or 500 msec SOA), the target was masked, and subjects were required to report the target's identity (perceptual identification).

It was found that first studying a homograph in context (e.g., hen-CHICK) reduced the likelihood of identifying a target incongruous with it (girl) compared to no-study subjects who saw the primers for the first time. Prior study of homographs appears to constrain their interpretation on re-presentation, even if the processing time for the homograph is short (200-msec SOA). However, the effect of prior study was small, and there was no facilitation of responses to either subordinate or dominant associates using an SOA of 200 msec. (Two subsequent experiments using perceptual identification have shown a consistent superiority of report for dominant associates over subordinate associates, even if the SOA is short (e.g., 184 msec). Perceptual identification, in not showing effects parallel to response time, was abandoned, at least for purposes of exploring the issue of multiple access.)

The Experiments

Four experiments are reported that employed a study/test procedure in which homographs were first studied and then used as primers in a response-time task. The first three experiments (Experiments 5a, 5b, and 5c) were similar in design and used lexical decision as the priming task, so they will be presented together. The final experiment (Experiment 6) used rapid pronunciation instead of lexical decision, and will be presented separately. A summary will first be given of the basic procedure and rationale for the three lexical-decision experiments.

Lexical-decision experiments

In the first experiment (Experiment 5a), subjects either first studied homographs in sentences or had no pre-exposure, a variable that was manipulated between subjects. In the study group, subjects read sentences containing homographs that biased either a subordinate or the dominant meaning. After reading each sentence, a critical word from the sentences (the homograph) was presented alone so that processing could be focused on the homograph, and the subject's task was to remember the critical word for later recall.

The next phase of Experiment 5a required subjects to decide rapidly if letter-strings were words or nonwords (lexical decision). The letter-strings were preceded by homographic primers that had either been studied (study group) or not studied (no-study groups). The critical lexical-decision trials were "word" trials in which the target was either a subordinate or a dominant associate of the homographic primer (e.g., bowl - alley or bowl - cereal, respectively), or an unrelated word (e.g., bowl - snow). For the study group, the target items were new associates that were either related to the meaning biased during study (dominant study-dominant test, or subordinate study-subordinate test), or unrelated to the meaning biased during study (dominant study-subordinate test, or subordinate study-dominant test). For the no-study group, both the homographic primer and the target were new.

Because primary interest was in the effect of context at a short SOA, the sentence study group was tested using an SOA of 284 msec, and one no-study group was tested using the same SOA. The no-study group was expected to show facilitation in both subordinate and dominant conditions, and the critical question was how the study group would compare. An additional no-study group was tested using a long SOA (1500 msec) to ensure that the baseline effect of interest was produced, namely, facilitation of responses to only dominant associates. (The two no-study conditions were therefore a between-subjects replication of Experiments 1 and 2 using lexical decision instead of pronunciation).

The experiment also included a final cued-recall test for pair members in the lexical-decision phase. Recall was included as an additional test of the hypothesis - discussed for Experiments 1 and 2 - that episodic encoding is influenced by SOA in the reaction-time task. Experiment 1 showed a small attentuation of the advantage for recall of dominant pair members using a short SOA (284) compared to a long SOA (901 msec). The same comparison of recall was made between the no-study groups, one tested using a short (284 msec) and the other tested using a long SOA (1500). The other comparison of interest for recall was between the no-study and sentence-study groups tested at 284-msec SOA. The question was how prior exposure to the homographs in biasing sentences influenced encoding of pair members in the lexical-decision task. On the assumption that sentence study would create an encoding bias toward the studied meaning for subsequent presentations of the homograph (a context effect), it was predicted that for the sentence-study group there would be an advantage in recall of pair members in the lexical-decision task that were congruous with the studied meaning, and impaired recall for members that were incongruous with originally studied meaning. In summary, it was expected that the no-study, long-SOA group would show a strong advantage for recall of dominant pair members, the no-study, short-SOA group would show equality of recall for subordinate and dominant pair members, and the sentence-study, short-SOA group would show an advantage for contextually congruous pair members.

The next two experiments in the series (Experiment 5b and 5c) were identical in design to the study condition of Experiment 5a, but a stronger study manipulation was employed. Instead of studying the homographs in sentences, they were studied with an associate of either a subordinate or the dominant meaning (paired-associate study). Furthermore, because the homographs were studied with single words, the bias induced by the study manipulation could be assessed by having subjects attempt to recall the studied associate given the studied homograph as a cue. This was in addition to the requirement to recall pair members from the lexical-decision trials.

The third experiment in the series (Experiment 5c) used paired-associate study, as did Experiment 5b, but a shorter SOA was employed in the lexical-decision phase (184 msec instead of 284 msec). This experiment was a direct consequence of an interesting context effect in Experiment 5b. Apart from the shorter SOA, Experiment 5c was in all respects the same as Experiment 5b.

Pronunciation experiment

Experiment 6 attempted to extend the generality of a context effect found in Experiment 5b (paired-associate study) to a pronunciation task. In this experiment, context (no-study vs. study) was manipulated within rather than between subjects, and will be discussed in detail after the three lexical-decision experiments are presented.

Experiment 5a

Method

Subjects

Forty-eight subjects participated in the experiment to fulfil a course requirement in introductory psychology at McMaster University. Sixteen subjects were randomly assigned to each of three groups: sentence-study (tested using an SOA of 284 msec); no-study (tested using an SOA of 284 msec); and no-study (tested using an SOA of 1500 msec).

Apparatus

An Apple II computer and Comrex monitor (amber on black) were used for stimulus presentation, stimulus timing, and measurement of response times. All timing was controlled by a machine language program, a Mountain Hardware Clock, and was accurate to 1 msec. Subjects made their word/non-word responses by pressing one of two telegraph keys, the dominant hand assigned to a "word" response and the non-dominant hand to a "non-word" response. Recall was a paper and pencil test.

Design

There were three between-subjects conditions: one no-study group tested at 284-msec SOA, one no-study group tested using 1500-msec SOA, and a sentence-study group, tested using 284-msec SOA. For each group, the within-subjects variables were as follows. (1) Word/non-word targets: Letter-string targets in the lexical-decision task were either words or pronounceable non-words, a variable that was included only to make a lexical-decision task. Only the "word" trials were analyzed. (2) Relatedness: Word targets were preceded by a homographic primer that was either unrelated or related to a target word. (Non-word targets were also preceded by homographic primers drawn from a separate pool of homographs.) (3) Test dominance: Word targets in the related condition were either subordinate associates or dominant associates of the homographic primer. Test dominance for unrelated trials was a counterbalancing variable to ensure that estimates of mean response time for unrelated "subordinate" and "dominant" trials were based on the same nominal items as estimates for related subordinate and dominant trials.

In addition to the above within-subjects variables, for the sentence-study group there was a manipulation of (4) study dominance. Subjects studied either the dominant or subordinate meaning of a homograph which, when crossed with two levels of test dominance, yielded 4 study dominance/test dominance conditions: two in which the studied and tested meaning were congruous (dominant test-dominant study and subordinate test-subordinate study) and two in which the studied and tested meanings were incongruous (dominant study-subordinate test and subordinate study-dominant test).

The final phase of the experiment was a cued-recall test. In this test, subjects attempted to recall either the primer (homograph) given a target (associate) as a cue, or a target (associate) given a primer (homograph) as a cue. These comprised two levels of a <u>cue type</u> variable. For the sentence-study group, the additional study-dominance variable made it possible to conditionalize recall of lexical-decision pair members on whether the homograph was originally studied in a sense congruous or incongruous with the meaning presented in the lexical decision phase.

<u>Materials</u>

<u>Study sentences</u>. For the sentence-study condition, two sentences were generated for each homograph, one sentence to bias a dominant meaning and one a subordinate meaning. For example, for the homograph <u>sign</u>, the sentence "To cash a cheque you have to sign it" biased a subordinate meaning, and the sentence "The highway sign indicated a detour" biased the dominant meaning.

<u>Lexical-decision word trials</u>. Ninety-six word triplets, each including a homograph, a dominant associate,

and a subordinate associate, were selected from the appropriate norms for homographs (see Method, Experiments 1 and 2). As in the other experiments, the 96 triplets were divided into 8 blocks of 12 items such that the average word length and frequency of the dominant and subordinate associates serving as targets were roughly equal across blocks.

For the sentence-study group, each of the 8 blocks was assigned equally often to one of 8 within-subjects conditions (2 relatedness X 2 test dominance X 2 study dominance), creating 8 presentation lists of 96 pairs. The related conditions (subordinate and dominant) were created by pairing a homograph with either its subordinate or dominant associate, and the unrelated conditions ("subordinate" and "dominant") were created by first creating the corresponding related condition, then randomly re-pairing homographs and associates within each block. For the no-study groups, two adjacent blocks were combined to form 4 blocks of 24 pairs, each assigned equally often to one of 4 conditions (2 relatedness X 2 test dominance).

Lexical-decision non-word trials. To create an equivalent number of non-word trials, 96 non-words were generated by taking a different pool of homographs (those with two noun meanings) and their associates and switching and/or replacing two or three letters of each associate to form a pronounceable non-word. The homographs and corresponding non-words were then randomly re-paired to create the final homograph/non-word pairs.

Examples of trial types can be found in Table 11. The stimuli for non-word trials can be found in Appendix C. For word trials in the lexical-decision phase, Appendix A can be consulted, and for study pairs, Appendix B.

Procedure

Subjects were tested individually in a session lasting approximately 1 hour. At the beginning of the session, subjects in the no-study groups were given instructions for the lexical-decision task, and informed that their memory for pair members would be tested after the lexical-decision phase by a cued-recall test. Those in the sentence-study group were first given instructions on the study procedure. This included informing them that a single word in each sentence was to be memorized for a later recall test (although they were not explicitly tested for study words). They were also informed at this point that lexical-decision trials would follow the study trials and that their recall for these items would also be tested. Sentences were read by subjects silently, after which they initiated presentation of the critical to-be-remembered word (the homograph) by pressing the space bar on the computer. The homograph was flashed for 500 msec at a marked location below the sentence. The homograph was presented separately as a to-be-remembered item

Table 11

The three phases of Experiment 5a, with examples for the homograph <u>sign</u> (and <u>refrain</u>).

<u>Phase I</u>: <u>Study</u>
(For study group only)

Dominant: To cash a cheque, you have to sign it.
Subordinate: The highway sign indicated a detour.

(Dominant: You are advised to refrain from smoking.)
(Subordinate: Popular tunes often have a catchy refrain.)

<u>Phase II</u>: <u>Lexical Decision</u>
(All subjects)

Condition	Primer - Target
Related dominant:	sign - name
Related subordinate:	sign - road
Unrelated "dominant":	refrain - name
Unrelated "subordinate":	refrain - road

<u>Phase III</u>: <u>Cued Recall</u>
(All subjects)

Cue - Target
sign - (name)
name - (sign)
refrain - (name or sign)
name or sign - (refrain)

in order to focus processing on it; it was flashed for a short duration in order to give subjects initial experience of the homograph as similar as possible to what they would receive in the lexical-decision trials.

Each lexical-decision trial included the following sequence of events. A fixation point (+) was presented at the center of the screen for 1 sec, followed by a blank interval of 1 sec. Then the primer was presented with an on-time of 100 msec, followed by a blank inter-stimulus interval of such a duration that the on-time and inter-stimulus interval summed to the required SOA (either 284 msec or 1500 msec). Onset of a target letter-string initiated the response timer. "Word" responses were indicated by pressing a telegraph key with the index finger of the dominant hand, and "non-word" responses by pressing another telegraph key with the index finger of the non-dominant hand. Subjects were instructed to respond "rapidly and accurately", and were informed that both their reaction times and errors were being recorded. Twenty practice trials preceded the experimental trials.

After completion of the lexical-decision phase, subjects were presented with precise instructions for cued recall. Cueing words were either primers (homographs) or targets (associates) from the "word" trials in the lexical decision phase, and the subject was instructed to recall the corresponding pair member from the lexical-decision trials.

The cue words were printed on sheets of paper with blanks for writing the response, and subjects were given approximately 20 minutes to complete the test. Debriefing followed the experiment.

Results

Lexical decision

Analyses of variance were conducted on the median latencies per cell for correct "word" trials, and errors rates in categorizing letter-strings. The rejection level for all comparisons was set at alpha < .05.

No-study groups. The first comparison of interest is between the no-study groups, one tested at 284-msec SOA and one at 1500-msec SOA. The expectation was that facilitation would obtain for both subordinate and dominant conditions at the short SOA, but only for the dominant condition at the long SOA. Mean response times (msec) for "word" trials and error rates are presented in Table 12.

A priori, one-tailed *t*-tests ($t_{crit}(2,90) = 1.65$, $MS_{e(res)} = 1022.00$) of the difference between each related condition and its unrelated control confirmed the expectation: There was reliable facilitation for subordinate ($t = 3.39$) and dominant ($t = 2.66$) conditions at 284-msec SOA, and for the dominant conditions at 1500-msec SOA ($t = 2.89$), but not for the subordinate condition at 1500-msec SOA

($\underline{t}$ = .81).

Error rates were analyzed by a mixed-design analysis of variance, with group (SOA), relatedness, and dominance as factors. No reliable differences between conditions were found (all $\underline{p}$s > 1.0).

Sentence study. Turning to the results for the sentence-study group, the expectation was that if facilitation using a short SOA is not affected by context - as it should be if access is independent of context - then being tested with a different meaning than was studied should not alter the general pattern of facilitation observed in the no-study group at 284-msec SOA. This was indeed the result. The means and error rates for conditions are presented in Table 13.

Table 12

Mean response times (msec) and errors (%) for the no-study conditions in the lexical-decision task of Experiment 5a.

		Target	
		Subordinate	Dominant
1500 SOA	Unrelated	582 (3)	585 (5)
	Related	573 (5)	551 (3)
		---	---
	Diff.	9	34
284 SOA	Unrelated	573 (6)	560 (5)
	Related	535 (4)	530 (3)
		---	---
	Diff.	38	30

A repeated-measures analysis of variance, with relatedness, test dominance, and study dominance as variables, showed a reliable effect of only relatedness, $F(1,15) = 27.41$, $MS_e = 1361.47$: Words preceded by related homographs were responded to faster than words preceded by unrelated homographs (all other Fs < 1.7). Analysis of the error rates (which, for unknown reasons were very high) showed no reliable effect of any variable (all Fs < 1.0, except the test dominance X study dominance interaction, $F(1,15) = 2.07$, $p < .17$).

The important result from the lexical-decision phase of this experiment is that the amount of facilitation was unaffected by the study manipulation: Times to respond to both subordinate and dominant associates were facilitated by

Table 13

Mean response times (msec) and errors (%) for "word" trials of the lexical-decision task for the sentence study conditions of Experiment 5a.

Dominance at Study	Subordinate		Dominant	
Dominance at Test	Sub	Dom	Sub	Dom
Unrelated	606 (14)	580 (18)	606 (15)	601 (16)
Related	567 (15)	565 (17)	568 (17)	555 (15)
	---	---	---	---
Diff.	39	15	38	45

a homographic primer approximately the same amount, whether the homograph was seen for the first time (38 and 30 msec), or previously studied in a sense congruent with the tested meaning (39 and 38 msec) or incongruent with the tested meaning (15 and 45 msec). Assuming that the context manipulation was effective, these data support the conclusion that "accessing" both subordinate and dominant meanings of homographs is not affected by prior context, a conclusion consistent with other experiments that have used biasing context and short SOAs.

Cued recall

The main interest in recall was to assess the effect on episodic memory of conditions in the lexical-decision task presumed to reflect operations of access (short SOA) or selection (long SOA). Processing in the short-SOA condition, insofar as it reflects access but not selection, should not affect the usual superiority of recall of dominant-pair members (the dominance effect). The dominance effect should nonetheless be strong in the long-SOA condition because a subordinate associate should be treated as an unrelated word. Therefore, to the extent that the short-SOA condition shows less effect of dominance than the long-SOA condition, there is support for Koriat's (1981) hypothesis that facilitation observed in a short-SOA condition is a consequence of the target itself having some selective effect on the homographic primer.

The mean proportions of items correctly recalled for the two no-study groups are presented in Table 14. Only recall of related pair members will be discussed because nothing of interest was found for the unrelated condition. A mixed-design analysis of variance, with SOA as the grouping factor and dominance and cue type (homograph or associate) as within-subjects factors, indicated that only the effect of test dominance was reliable, $\underline{F}(1,30) = 5.34$, $\underline{MS}_e = 0.292$ (.23 and .30, subordinate and dominant conditions, respectively). Although inspection of the difference scores for the two SOAs shows attenuation of the dominance effect from the long SOA to the short SOA, the interaction of SOA and test dominance

Table 14

Mean proportion of homographic primers (HOMOG) and associated targets (ASSOC) correctly recalled from the lexical-decision phase, given the pair member as a cue, for the no-study conditions in Experiment 5a.

			Pair Type in Lexical Decision			
			UNREL'D	RELATED		
SOA	cue	TARGET		Subordinate	Dominant	Diff.
284	homog	ASSOC	.05	.24	.28	.04
	assoc	HOMOG	.08	.23	.23	.00
1500	homog	ASSOC	.04	.20	.34	.14
	assoc	HOMOG	.08	.24	.32	.08

was not reliable, $F(1,30) = 2.72$, $MS_e = 0.292$. (All other Fs < 1.15).

Subjects in the sentence-study group were also required to recall pair members from the lexical-decision phase of the experiment. If it is assumed that study results in a contextually-dependent episodic representation of the homograph, then recall of pair members from the lexical-decision phase that were congruous with the studied sense (i.e., subordinate study - subordinate test and dominant study - dominant test) should be greater than recall of pair members that were incongruous with the studied sense (subordinate study-dominant test and dominant study-subordinate test). The mean proportions of primers (homographs) and targets (associates) correctly recalled from the lexical-decision phase are presented in Table 15. Only the results for the related pairs are discussed; nothing of interest emerged for unrelated pairs.

A repeated-measures analysis of variance for the related conditions, with study dominance (subordinate or dominant), test dominance (subordinate or dominant) and cue type (homograph or associate) as factors, indicated that the only important variable for recall was test dominance, $F(1,15) = 15.64$, $MS_e = 0.024$. Members of dominant pairings (.25) were better recalled than members of subordinate pairings (.145). Apart from an unreliable advantage in recall if the subordinate meaning was studied (.22) rather than the dominant meaning (.175), $F(1,15) = 3.17$, MS_e = 0.022, $p < .10$, all other Fs < 1.0.

Whereas there was considerable attenuation of the dominance effect for the no-study group (284-msec SOA; Table 14), there was a large dominance effect for the sentence-study group tested using the same SOA (Table 15). Comparison of the relevant entries in the tables shows that recall of dominant pair members was identical for the two conditions (.255 and .25, no-study and sentence study, respectively), whereas recall for subordinate pair members was reduced substantially for sentence study (.244 vs. .14, respectively). This result does not support the assumption

Table 15

Mean proportions of homographic primers (HOMOG) and associated targets (ASSOC) correctly recalled from the lexical-decision phase, given the pair member as a cue, for the sentence-study condition in Experiment 5a.

			Pair Type in Lexical Decision			
			UNREL'D	RELATED		
Study Dom.	cue	TARGET		Subordinate	Dominant	Diff.
SUB.	homog	ASSOC	.00	.15	.28	.13
	assoc	HOMOG	.02	.16	.29	.15
DOM.	homog	ASSOC	.00	.14	.25	.11
	assoc	HOMOG	.02	.13	.18	.05

that the context manipulation was effective. Whereas one might expect study of a dominant meaning to add strength to the otherwise strong pre-existing dominant bias, one would not expect study in a subordinate context to have an antagonizing effect on recall of subordinate pair members.

Experiments 5b and 5c

It is doubtful that an effective semantic bias of the homographs was induced by the sentence study procedure of Experiment 5a. One reason is that there was a dominance effect rather than a context effect in recall of pair members from the lexical-decision phase. Also, subjects in the sentence-study group were questioned about the study procedure, and they often reported being aware of the ambiguity of to-be-remembered words (homographs) during study.

Therefore, a different biasing manipulation was adopted for Experiments 5b and 5c. Instead of using homographs in sentences, each homograph was paired with a subordinate or dominant associate (e.g., chorus - refrain, cease - refrain), and subjects studied each associate-homograph pair for a subsequent cued-recall test. A number of pilot subjects indicated that this method of biasing was much more powerful than the sentence procedure.

Experiment 5b was identical to the sentence-study condition of Experiment 5a (284-msec SOA) except for paired-associate study, and Experiment 5c was identical to Experiment 5b except for a reduced SOA (184 msec) in the lexical-decision phase. The reduction in SOA for the latter experiment was prompted by the finding of a substantial context effect in Experiment 5b, and was used to test the possibility that prior study of homographs shortens their subsequent processing time as primers enough to enable an episodic influence within 284 msec of target onset, but not within 184 msec of target onset. Therefore, the question was whether the basic operations of access and selection were altered by prior study of the homographs, or whether there was simply a speeding of the same sequential processes.

Because Experiments 5b and 5c were identical except for SOA in the lexical-decision phase, they will be reported together. In each experiment a group of subjects first studied homographs with either subordinate or dominant associates, then performed a lexical-decision task in which, on the critical "word" trails, the studied homographs were primers for new words, either subordinate associates, dominant associates or unrelated words. The final phase of each experiment was cued recall. However, subjects were required to recall pair members from <u>both</u> the lexical-decision phase and the study phase. As for sentence study in Experiment 5a, evidence was sought in recall from the lexical-decision phase for an encoding bias induced by the study procedure. Recall from the study phase itself allowed a more direct assessment of this bias. The studied homographs were used as cues and subjects attempted to recall the associates with which they were studied. An effective biasing procedure should equate the cue-value of a homograph for its subordinate and dominant associates. Furthermore, because each studied homograph was used in the lexical-decision phase as a primer for either an unrelated word, a subordinate associate, or a dominant associate, it was possible to conditionalize recall of studied associates on the kind of intervening trial in the lexical-decision phase. Thus conditionalized, interest was focused on the impact of kinds of intervening trial on the cue-value of a homograph for its originally studied associate as a means of inferring processing in the lexical-decision phase. On the assumption that the processing of homographs in the lexical-decision phase entails access, but not selection (because the SOA was short), recall of studied associates should not be differentially affected by the kind of intervening trial.

A single Method section serves both experiments.

Method: Experiments 5b and 5c

Subjects

Sixteen subjects participated in each experiment for course credit in introductory psychology at McMaster University.

Apparatus and Materials

The apparatus, and stimulus materials for the lexical decision task, were identical to those employed in Experiment 5a (see Method section, Experiment 5a). There were 96 word trials and 96 non-word trials. For the study phase, the associates used in Experiments 3 and 4 were paired with the homographs (see Appendix B).

Design

The variables in the experiments were (1) word/non-word targets, (2) relatedness of pairs in lexical decision, (3) test dominance, or dominance of the pairing in the lexical-decision trials, and (4) study dominance, either congruous or incongruous with test dominance. Analyses were conducted on only "word" trials, so the design for response times was a 2 relatedness (unrelated and related) X 2 test dominance (subordinate and dominant) X 2 study dominance (subordinate and dominant) repeated measures. The design for cued recall of related pair members from the lexical-decision phase was a 2 test dominance X 2 study dominance X 2 cue type (primer cue and target cue) repeated measures. The design for cued recall from the study phase was a 2 study dominance X 2 relatedness (of the intervening lexical-decision trials) X 2 test dominance (of the intervening lexical-decision trials) repeated measures.

Procedure

Subjects were given detailed instructions about the study task and the lexical decision task before commencing the study phase. On each study trial, a subordinate or dominant associate and the homograph were presented side by side on the computer monitor, with the associate always presented in the left position. Subjects studied each pair at their own pace, and were instructed that they would later be required to recall one pair member given the other as a cue.

After subjects completed studying the 96 pairs, the lexical-decision phase began. The experimental trials were preceded by 20 practice trials in which primers and targets were new words, and 15 of the 20 were related pairs. All aspects of the lexical-decision phase were identical to Experiment 5a.

Immediately after the lexical-decision phase, subjects were given detailed instructions for cued recall. The cues were either homographs (presented both in the study phase and, as primers, in the lexical-decision phase) or associates (from the lexical-decision phase). Subjects were instructed to write in the blank space beside the cue word (1) the word with which it was paired in the lexical-decision phase, and in parentheses (2) the word with which it was paired in the study phase, if they had seen the cue word in that phase. Because homographs were presented with different words in the study and lexical-decision phases, two words could be recalled for homographic cues, either two dominant associates, two subordinate associates, one dominant and one subordinate associate, or an associate and an unrelated word. For cues that were associates from the lexical-decision phase, subjects could correctly recall a homograph (either related or unrelated) and indicate, by not enclosing it in parentheses, that it had appeared in the lexical decision phase.

Results: Experiments 5b and 5c

Response times for lexical decisions will first be discussed for both experiments, followed by lexical-decision recall and study recall. Alpha < .05 was considered significant.

Lexical decision

Experiment 5b. This experiment differed from the sentence-study group of Experiment 5a only in form of study; the SOA was the same (284 msec). Mean response times (based on cell medians) to respond correctly on "word" trials, and the percentage of errors (in parentheses), are presented in Table 16.

Inspection of the differences between related and unrelated pairs shows that "facilitation" obtained only if the homograph was studied with a dominant associate (46 and 60 msec), not a subordinate associate (-10 and 3 msec). This was confirmed by a repeated-measures analysis of variance, with relatedness, test dominance, and study dominance as factors: The only reliable effect in the analysis was the interaction of relatedness and study dominance, $F(1,15) = 7.36$, $MS_e = 3437.84$. Simple main effects analysis indicated that the interaction was the result of longer times to respond to <u>unrelated</u> words in the dominant-study condition (629 msec) than either related words in the dominant-study condition (576 msec), unrelated words in the subordinate-study condition (586 msec), or related words in the subordinate-study condition (589 msec), all of which were equal. (Each of the main effects of the two variables in this interaction were marginally reliable, $Fs(1,15) = 3.64$ and 3.02, $ps < .08$; no other effects approached significance in the experiment, $Fs < 1.00$.)

Table 16

Mean latencies (msec) and errors (%) for "word" trials in the lexical-decision task of Experiment 5b.

Dominance at Study	Subordinate		Dominant	
Dominance at Test	Sub.	Dom.	Sub.	Dom.
Unrelated	590 (5)	581 (6)	627 (7)	631 (4)
Related	600 (3)	578 (5)	581 (5)	571 (3)
Diff.	-10 (2)	3 (1)	46 (2)	60 (1)

The interesting, and curious, aspect of this context effect is that it is the result of a reduction in time to respond to unrelated words if they were primed by a homograph that was studied with a subordinate associate. This raises the possibility that "facilitation" using a short SOA is not a benefit for responses to target words that are related to the homographic primer, but a cost for responses to targets unrelated to the homographic primer, a possibility that is discussed further below.

Analysis of errors in categorizing letter-strings as words (in parentheses, Table 16) revealed only a marginal interaction of test dominance and study dominance, $F(1,15) = 4.31$, $MS_e = 0.003$ ($p < .06$): Errors were more frequent if the tested meaning was incongruent with the studied meaning (5.5% for subordinate study-dominant test, and 6% for dominant study-subordinate test), than if the tested meaning was congruent with the studied meaning (4% for subordinate study-subordinate test, and 3.5% for dominant study-dominant test. (All other $F < 1.0$.)

Experiment 5c. This experiment differed from Experiment 5b only in that a shorter, 184-msec SOA was used in the lexical-decision phase. The mean response times for correct "word" responses (based on cell medians) and the percentage of errors (in parentheses) are presented in Table 17.

Inspection of the difference scores shows that "facilitation" is reinstated for all conditions. This was verified in a repeated-measures analysis of variance by a reliable effect of relatedness, $\underline{F}(1,15) = 9.7$, $\underline{MS}_e = 5448$. The only other significant effect was that dominant associates (collapsed across relatedness) were responded to more rapidly (611 msec) than subordinate associates (638 msec), $\underline{F}(1,15) = 6.43$, $\underline{MS}_e = 3621$. (This likely reflects some artifactual difference between the set of dominant and subordinate associates; a similar trend was noted in the no-study condition of Experiment 5a, although it has not been consistently observed.) Apart from an unreliable tendency for responses to be faster if the subordinate meaning was studied (613 msec) than if the dominant meaning was studied (630 msec), $\underline{F}(1,15) = 2.45$, $\underline{p} < .14$, all other $\underline{F}$s < 1.0 in

Table 17

Mean latencies (msec) and errors (%) for "word" trials in the lexical-decision task of Experiment 5c.

Dominance at Study	Subordinate		Dominant	
Dominance at Test	Sub.	Dom.	Sub.	Dom.
Unrelated	639 (8)	621 (4)	676 (10)	641 (5)
Related	604 (7)	588 (3)	631 (5)	593 (2)
Diff.	35 (1)	32 (1)	45 (5)	48 (3)

the analysis.

These results are consistent with the view that the episodic effect observed in Experiment 5b takes time to exert its effect, but that the basic processes have not been changed. It is nonetheless of interest that the pattern of response times in the present experiment is similar, though much less pronounced, to that of Experiment 5b using 284-msec SOA. In particular, responses to unrelated words primed by a homograph studied with the dominant associate were slower than responses to unrelated words primed by a homograph studied with a subordinate associate (676 and 641 msec vs. 639 and 621 msec, respectively). In short, the context effect found in Experiment 5b still seems to be present using the shorter SOA, but in an attenuated form.

Errors in lexical decisions had virtually the identical pattern as did latencies. These are presented for conditions (in parentheses) in Table 17. A repeated-measures analysis of variance on the errors, with relatedness, study dominance, and test dominance as variables, indicated that there were fewer errors in the related condition (4.25%) than the unrelated condition (7.5%), $F(1,15) = 9.98$, $MS_e = 0.002$, and, collapsed across relatedness, fewer errors in categorizing dominant associates (3%) than subordinate associates (7.5%), $F(1,15) = 4.87$, $MS_e = 0.011$. No other effects were reliable by the analysis (Fs < 1.0).

To summarize, the results from lexical-decision task for the two paired-associate experiments were the following. (1) If tested using 284-msec SOA, prior study of homographs with subordinate associates reduced the time to respond to unrelated words primed by the studied homograph, eliminating any difference between the related and unrelated conditions. (2) This latter context effect depended on SOA. If the SOA was 284 msec, the reduction for the unrelated, subordinate-study condition was observed, but if the SOA was 184 msec, response times were once again increased for these unrelated words, re-instating "facilitation" for subordinate and dominant conditions, an effect that was independent of the congruity of dominance between study and test.

Cued recall

The recall task will be briefly outlined again. Cue words were from the "word" trials of lexical-decision phase of the experiment. If a homograph was the cue, subjects could correctly recall (1) an associate with which the homograph was paired during the study phase, and (2) an associate or unrelated word with which it was paired during the lexical-decision phase. If an associate was the cue, subjects could correctly recall only the homograph and assign its occurrence to the lexical-decision phase. Recall of pair members from the lexical-decision phase and of associates from the study phase will be presented separately.

Experiment 5b: Lexical-decision recall. The mean proportions of primers and associates correctly recalled from the lexical-decision phase of Experiment 5b are presented in Table 18. Only recall of related pair members will be discussed because nothing of interest emerged for recall of the unrelated pairs (see Table 18). For recall of related pair members, the expectation was that if paired-associate study biased subsequent processing of homographs, then pair members in the lexical-decision phase congruous in meaning with the studied meaning would be better recalled than pair members incongruous in meaning with the studied meaning. In

Table 18

Mean proportions of homographic primers (HOMOG) and associated targets (ASSOC) correctly recalled from the lexical-decision phase, given the pair member as a cue, for conditions in Experiment 5b. (Parenthesized values are proportions mis-attributed to the study phase of the experiment, and are included in the overall proportions correctly recalled.)

			Pair Type in Lexical Decision			
			UNREL'D	RELATED		
Study Dom.	cue	TARGET		Subordinate	Dominant	Diff.
SUB	homog	ASSOC	.03	.05 (.03)	.13 (.03)	.08
	assoc	HOMOG	.01	.23 (.09)	.16 (.04)	-.07
DOM	homog	ASSOC	.02	.10 (.02)	.19 (.06)	.09
	assoc	HOMOG	.02	.11 (.03)	.29 (.11)	.18

other words, a context effect was expected, rather than a dominance effect.

A repeated-measures analysis conducted on the related pairs included study dominance, test dominance, and cue type as variables. Because the three variables reliably interacted, the other lower-level effects will be briefly mentioned before discussing the interaction. The main effects of study dominance and test dominance were, respectively, marginal ($p < .06$) and significant, $Fs(1,15)$ = 4.01 and 4.77, MS_es = 0.015 and 0.033. The main effect of cue type was reliable, $F(1,15) = 5.56$, $MS_e = 0.037$, reflecting that homographs were poorer cues for recalling associates (.12) than associates were for recalling homographs (.20). The two-way interaction of study dominance and test dominance was reliable, $F(1,15) = 13.97$, MS_e = 0.010, reflecting that recall was greater for dominant pair members if the dominant meaning was studied (.24) than for dominant pair members if the subordinate meaning was studied (.105) or for subordinate pair members if either the dominant (.145) or subordinate (.14) meaning was studied.

Finally, there was a significant study dominance X test dominance X cue type interaction, $F(1,15) = 10.35$, MS_e = 0.011. The interaction can be readily understood if the difference scores are examined in Table 18, first for cues that were homographs, then for cues that were associates. If a homograph was the cue, recall of dominant pair members was greater then recall of subordinate pair members, regardless of which meaning of the homograph was originally studied; in other words, a dominance effect. If, on the other hand, an associate was the cue, the homograph was recalled best if it had first been studied in a sense congruous with that of the cue word; in other words, a context effect. All the difference scores were reliable, $t_{crit}(2,105) = .07$, $MS_e = 0.011$.

The presence of a context effect in cued-recall from the lexical-decision phase demonstrates that paired-associate study was more biasing than sentence-study in Experiment 5a. However, this context effect was limited to the condition in which the associate was the cue for recalling the homograph; a homographic cue showed a consistent bias toward the dominant meaning, regardless of which meaning was studied.

Experiment 5b: Study recall. Two questions were asked about study recall: First, was biasing as effective for a subordinate meaning as a dominant meaning? Second, how did recall from the study phase vary as a function of the kind of intervening pair in the lexical-decision phase? Recall of associates from the study phase, given the homograph as a cue, are presented in Table 19 as a function of the kind of lexical-decision trial intervening between study and recall.

A repeated-measures analysis of variance, with study dominance, test dominance, and relatedness as factors, indicated only a main effect of study dominance: Recall of dominant associates was superior (.51) to recall of subordinate associates (.36), $F(1,15) = 16.11$, $MS_e = 0.045$. Apart from a small, unreliable advantage in recall if the intervening lexical-decision trials were related pairs (.465) rather than unrelated pairs (.40), $F(1,15) = 3.53$, $MS_e = 0.042$, $p < .08$, no other effects approached significance in the analysis (Fs < 1.52).

The results for recall of studied associates is therefore consistent with the inference drawn from lexical-decision recall: A homographic cue is biased in favour of a

Table 19

Mean proportions of associates correctly recalled from the study phase, given the homograph as a cue, as a function of the type of lexical-decision trial intervening between study and recall, for Experiment 5b. Note: Dom = Dominant; Sub = Subordinate.

	Intervening lexical-decision trial				
	Unrelated		Related		
Associate at study	Sub	Dom	Sub	Dom	Mean
Subordinate	.29	.36	.41	.36	.36
Dominant	.48	.46	.55	.54	.51
Mean	.39	.41	.48	.46	

dominant associate, even if the homograph was studied with a subordinate associate. This result also indicates that paired-associate study was not totally successful in biasing the interpretation of the homograph toward a subordinate meaning. Despite this, paired-associate study was apparently strong enough to bias recall of homographs in the lexical-decision phase, given an associated cue, and to create the context effect observed in response times.

Experiment 5c: Cued recall. Experiment 5c differed from Experiment 5b only in that an SOA of 184 msec was used in the lexical-decision phase. What, therefore, should be expected for recall in Experiment 5c from the lexical-decision phase and the study phase, respectively? Consider again briefly the findings for recall in Experiment 5b: Recall of pair members from the lexical-decision phase showed a context effect if the associates were cues for recalling homographs, but a dominance effect if homographs were cues for recalling associates. Recall from the study phase, in which only homographs were used as cues, showed a dominance effect.

Two prior experiments (Experiment 1 and Experiment 5a) have shown unreliable, but not trivial, attenuation of the dominance effect at a short SOA (compared to a long SOA). It was argued that this was consistent with Koriat's (1981) proposal that "facilitation" in the subordinate and dominant related conditions using a short SOA is the result of a selective effect of the associated target on the homograph. The small attenuation of the dominance effect is consistent with the hypothesis that the use of a short SOA enhances selection of the meaning specified by the related target item. The present experiment, in using a yet shorter SOA, should therefore increase the likelihood of the homograph being interpreted in terms of the contiguous associate. Furthermore, if prior paired-associate study was for the _same_ meaning as presented in lexical decision, then episodic bias should _further_ enhance the specificity of processing of the homograph. In short, the dominance effect for homographic cues observed in the prior experiment should be reduced if the subordinate meaning is studied, whereas it should be enhanced if the dominant meaning is studied; that is, an effect of _context_ would be expected for _both_ cues that are homographs and those that are associates.

For recall of associates from the _study_ phase, on the other hand, there is no reason to expect any change in the overall advantage for recall of dominant associates compared to recall of subordinate associates, because the study procedure was identical in the two experiments. However, if encoding of related pairs in the _lexical-decision_ phase is more strongly in favour of the contiguous, associated target, pair members in the lexical-decision phase might be expected to _interfere_ with recall from the study phase under certain conditions. In particular, subordinate, related pairings in the lexical-decision phase would be expected to interfere with recall of dominant associates from the study phase, whereas dominant, related pairings in lexical-decision phase would be expected to interfere with recall of subordinate associates from the study phase.

Experiment 5c: Lexical-decision recall. The mean proportions of associates and homographs correctly recalled from the lexical-decision phase are presented in Table 20. Only the related pairs are discussed; nothing of interest

Table 20

Mean proportions of homographic primers (HOMOG) and associated targets (ASSOC) correctly recalled from the lexical-decision phase, given the pair member as a cue, for conditions in Experiment 5c. (Parenthesized values are proportions mis-attributed to the study phase of the experiment, and are included in the overall proportions correctly recalled.)

			Pair Type in Lexical Decision			
			UNREL'D	RELATED		
Study Dom	cue	TARGET		Subordinate	Dominant	Diff.
SUB	homog	ASSOC	.00	.19 (.02)	.17 (.03)	-.02
	assoc	HOMOG	.01	.32 (.15)	.25 (.05)	-.07
DOM	homog	ASSOC	.01	.10 (.02)	.22 (.03)	.12
	assoc	HOMOG	.02	.20 (.05)	.23 (.08)	.03

emerged for the unrelated pairs.

The differences between recall of subordinate and dominant pair members (the right-most column of the table) show that the results are roughly in accord with expectation. There was a small advantage for recall of subordinate pair members if the subordinate meaning was studied, whether cued by a homograph (.19 vs. .17) or by an associate (.32 vs. .25), a pattern that was <u>reversed</u> if the dominant meaning was studied, whether cued by a homograph (.10 vs. .22) or an associate (.20 vs. .23). However, a repeated-measures analysis of variance, with study dominance, test dominance, and cue type as factors, showed that the critical interaction of study dominance and test dominance was not reliable, F = 2.58, MS_e = 0.044, $p < .10$ .. The only reliable effect in the experiment was cue type: Associates were better cues for recalling homographs (.25) than homographs for recalling associates (.17), $F(1,15) = 13.87$, MS_e = 0.015. All other Fs < 1.0, except for a marginal main effect of study dominance and a study dominance X cue-type interaction, Fs = 3.11 and 2.38, MS_e = 0.020 and 0.015, respectively; ps < .10.

<u>Experiment 5c: Study recall</u>. The proportions of associates correctly recalled from the study phase, given the homograph as a cue, are presented in Table 21. Recall was analyzed as a function of the type of intervening lexical-decision trial: related or unrelated (relatedness), and subordinate or dominant targets (test dominance). Hence, the

factors in the analysis were study dominance, relatedness, and test dominance, with repeated measures on each.

The analysis indicated a main effect of study dominance $F(1,15) = 9.93$, $MS_e = 0.046$: Dominant associates were better recalled (.43) than subordinate associates (.31), again demonstrating that there is a bias in the cue-value of a homograph toward its dominant meaning. The other reliable effect in the experiment was an interaction of relatedness and test dominance, $F(1,15) = 4.91$, $MS_e = 0.040$ (all other $Fs < 1.69$). Means for the interaction are presented in the bottom row of Table 21. The interaction shows that if the

Table 21.

Proportion of associates correctly recalled from the study phase, given the homograph as a cue, as a function of the type of lexical-decision trial intervening between study and recall, for Experiment 5c. Note: Dom = Dominant; Sub = Subordinate.

	Intervening lexical-decision trial				
	Unrelated		Related		
Associate at study	Sub	Dom	Sub	Dom	Mean
Subordinate	.30	.27	.30	.37	.31
Dominant	.52	.41	.38	.45	.44
Mean	.41	.34	.34	.41	

intervening lexical-decision pairs were related (right half of the table), subordinate pairs reduced recall of both subordinate and dominant studied associates (.34) relative to dominant pairs (.41), whereas if the intervening pairs were unrelated (left half of the table), "dominant" pairs reduced recall of both subordinate and dominant associates (.34) compared to "subordinate" pairs (.41). The interaction has been interpreted in terms of a reduction in recall because if the pattern of recall for Experiment 5b (Table 19) is compared with that of the present experiment (Table 21), recall is reduced from Experiment 5b to Experiment 5c primarily in these conditions. No convincing explanation can be offered for the interfering effect of unrelated, "dominant" lexical-decision trails, but there is a possible account of the interfering effect of intervening related, subordinate trials.

It was predicted that intervening subordinate pairs would reduce recall of only studied, dominant associates, not studied, subordinate associates. However, the fact that recall was reduced in both cases is consistent with the view that there was strong episodic encoding of subordinate pairs in the lexical-decision phase. To the extent that subjects tended to recall only a single item, whether from the lexical-decision or study phase (both possible items were recalled only 5% of the time), recall of an item with a strong episodic representation may have terminated subjects' retrieval attempts for a second item. If subordinate pairings were relatively well encoded at 184-msec SOA (e.g., there was a context effect in lexical decision, rather than a dominance effect), then recall of studied associates would be impaired because of the "recall one item" bias. Comparison of lexical-decision recall across Experiments 5b and 5c is consistent with this: Relative to recall of dominant pair members from the lexical-decision phase, recall of subordinate pair members from the lexical-decision phase of Experiment 5c was enhanced over that of Experiment 5b (.20 subordinate vs. .21 dominant (5c) and .12 subordinate vs. .17 dominant (5b)). That is, related, subordinate pair members were relatively well recalled from the lexical-decision phase of the present experiment (not differing from related, dominant pair members), and this may have interfered with recall of the studied items. The result is consistent with the conclusion that the 184-msec SOA in the present experiment conferred greater inter-item "cohesiveness" within lexical-decision pairs than did the 284-msec SOA in Experiment 5b, and that this effect was greater for subordinate pairings than for dominant pairings.

Summary of results: Experiments 5b and 5c

The results of Experiments 5b and 5c will be briefly summarized before presenting Experiment 6. Consider response times. (1) Experiment 5b showed that the difference between time to respond to words primed by a related homograph and those primed by an unrelated homograph can be eliminated if the homograph is first studied with a subordinate associate. (2) Experiment 5b also showed that the elimination of the advantage is the result of faster responses in the unrelated baseline condition. (3) Experiment 5c showed that, whatever the reason for such a context effect, further reducing processing time for the studied, homographic primer by reducing SOA re-instates the difference between the related and unrelated conditions. Now consider recall for the two experiments. (1) Using a 284-msec SOA (Experiment 5b), recall from the lexical-decision phase showed a context effect if the associate was the cue, whereas a dominance effect if the homograph was a cue, either for lexical-decision pairs or studied pairs. (2) Reducing the SOA to 184 msec (Experiment 5c) resulted in the elimination of the dominance effect in lexical-decision recall for homographic cues. Such a finding is consistent with Koriat's (1981) proposal that at short SOAs there is a selective effect of the target. However, this inter-item cohesiveness of encoding in the lexical-decision phase may have had a detrimental effect on recall of not only dominant associates from the study phase (which was expected), but of subordinate associates as well.

Experiment 6 focused on the reaction time results of the lexical-decision experiments, in particular the context effect of Experiment 5b, and its elimination in Experiment 5c. This latter finding implies either (a) that paired-associate study was not sufficiently strong (as indicated by study recall) and, had it been, the same effect observed using 284-msec SOA could be obtained using shorter SOAs, (b) that the effect of context was simply to speed processing, but not to alter the hypothetical stages of access and selection, as was proposed above, or (c) that the context effect is a peculiar characteristic of the lexical-decision task, possibly related to what has been called a "post-access decision process" (see, for e.g., DeGroot, 1984). Experiment 6 sought to test this last alternative.

Experiment 6

Because there are numerous performance differences between choice response-time tasks, like lexical decision, and simple response-time tasks, like pronunciation (see, for e.g., Forster, 1979), this experiment sought to answer the question "Is the context effect found in Experiment 5b limited to the lexical-decision task?" The experiment attempted to replicate the context effect using a pronunciation task. Apart from the task change, the present experiment was different in two other respects from the lexical-decision experiments. First, an attempt was made to replicate the effect of context on response times (Experiment 5b) <u>within</u> subjects, by having subjects study only half the homographic primers. If the results from the between-subjects design of the lexical-decision experiments are robust and, importantly, not a function of the lexical-decision task per se, then it would be predicted that: (1) priming with unstudied homographs will result in "facilitation" of responses to both subordinate and dominant associates, and (2) priming with studied homographs will eliminate this "facilitation" if the subordinate meaning is studied (by reducing time to respond in the unrelated baseline), but will not eliminate this "facilitation" if the dominant meaning is studied. The second difference between the present experiment and Experiment 5b is that there was no congruous-study condition in which subjects both studied and were tested with associates related to the same meaning (e.g., study "song-refrain"; test "refrain-CHORUS"). Rather, the homographic primers in the present experiment were always studied in a sense incongruous with the associated target (e.g., study "song-refrain"; test "refrain-CEASE", or study "stop-refrain"; test "refrain-CHORUS"). This was taken to be a relatively unimportant change because the context effect in the lexical-decision experiment was not affected by the congruity variable; it depended only on study dominance (there was no study dominance X test dominance interaction).

One further aspect of Experiment 6 should be mentioned. On the basis of Experiments 1 and 2 using pronunciation, an SOA of 184 msec was used, because facilitation of responses to both subordinate and dominant associates seemed to be maximal in the 184 msec SOA condition in those experiments. This meant, of course, that the same SOA (284 msec) in which the context effect was observed in the lexical-decision experiment (Experiment 5b) was not used. It seemed more advisable to ensure the baseline effect for unstudied homographic primers than to exactly replicate Experiment 5b; without a baseline of facilitation for both subordinate and dominant conditions, no reasonable interpretation of effects for studied homographic primers would be possible.

Finally, as in the lexical-decision experiments, episodic memory was tested by cued recall in a final phase of the experiment. Predictions for recall will not be discussed in detail here. As in the former experiments, recall for pair members in the pronunciation phase were tested, as well as for associates in the study phase. For the no-study condition it was expected that the dominance effect would be attenuated, as it was in Experiments 1, 2, and 5a (no-study groups). For the study condition, results similar to Experiment 5b and 5c were expected, but it was unclear how recall would vary as a result of other differences between the experiments.

The procedure for Experiment 6 was as follows. In the first phase of the experiment, subjects studied 48 homographs (half of the original list of 96 used in previous experiments), half paired with a subordinate associate and half with a dominant associate. In the second phase, subjects were presented with 96 pronunciation trials. On each trial a homographic primer, either studied or unstudied, was first presented, followed by a target word (184-msec SOA) that was either related (a subordinate or dominant associate) or unrelated to the homograph. Subjects were required to pronounce the homograph and response times were measured from onset of the target. In the third phase, recall cues were primers and targets from the pronunciation phase, and subjects attempted to recall words paired with the cues in the pronunciation and study phases.

Method

Subjects

Forty-eight subjects participated in the experiment for a course credit in introductory psychology at McMaster University, and were randomly assigned to conditions. There were an equal number of subjects (6) assigned to each of 8 list presentations, representing complete counterbalancing of items and conditions.

Apparatus and Materials

The apparatus included the same computer, monitor, and machine-language timing routines employed in the other experiments.

The same lists as in the pronunciation trials of Experiments 1 and 2 were employed in the pronunciation phase of the present experiment (see Appendix A), and the dominant and subordinate associates used in the study phase of the lexical-decision experiments were employed in the study phase of the present experiment (see Appendix B and Method section for Experiments 1 and 2, and 5b).

Results and Discussion

The results for the pronunciation phase will first be reported, followed by the results for cued recall. Alpha < .05 was considered significant.

Response times

All errors in pronunciation and failure to trip the voice-activated relay (1.7%) were eliminated from the analyses. Variables in the analyses included study (unstudied or studied homographic primers), relatedness (unrelated or related targets), and test dominance (subordinate targets or dominant targets). Note that for the subordinate study condition, homographic primers were studied with a dominant associate, whereas for the dominant study condition, homographic primers were studied with a subordinate associate.

Analysis of response times was initially based on cell medians, as in the other experiments. However, the effects using cell medians were small, resulting in a reliable effect of only relatedness. The results using cell means, on the other hand, presented a much clearer picture and are presented below. The medians showed comparable effects to means except for one cell in the design - the unrelated "subordinate", no-study condition - which was faster than the corresponding unrelated "dominant", no-study condition, consequently reducing "facilitation" in the no-study subordinate condition. The analysis using cell medians, and the overall means for conditions, are presented in Appendix D for comparison. It should therefore be borne in mind that the medians did not conform exactly to that of the means.

The mean response times (based on cell means), and differences between unrelated and related conditions, are presented in Table 22. A repeated-measures analysis of variance with relatedness, test dominance, and study as factors, indicated that the effect of relatedness was reliable, $F(1,47) = 14.83$, $MS_e = 584.85$ (575 vs. 566 msec, for unrelated and related conditions, respectively). Neither the main effects of dominance nor study were reliable, $Fs(1,47) = 2.28, 2.30$, $MS_es = 500.97, 893.00$. However, there was a reliable interaction of relatedness and study, $F(1,47) = 4.34$, $MS_e = 718.79$ (all other $Fs < 2.29$, $ps < .16$). Simple main effects analysis of the interaction indicated that associates preceded by unstudied, related homographs (collapsed across dominance) were pronounced more rapidly (15 msec) than associates preceded by unstudied, unrelated homographs, $F(1,329) = 9.50$, $MS_{e(res)} = 568.3$ (565 vs. 580 msec, respectively). On the other hand, there was no reliable difference (4 msec) between related and unrelated conditions if homographs were studied (567 vs. 571 msec, respectively). This result confirms the hypothesis that prior study of incongruous meanings of homographs can eliminate their "facilitative" effect as primers. The other critical hypothesis for which the interaction is relevant is that the difference in priming between the study and no-study conditions should result from a <u>decrease</u> in response time in the unrelated, study baseline, not an increase in the study, related conditions. The relevant comparisons showed that,

Table 22

Mean times (msec) to pronounce associates, and the difference between related and unrelated conditions, for Experiment 6.

	No study		Study	
			Dom.	Sub.
Dominance at Test	Sub.	Dom.	Sub.	Dom.
Unrelated	580	580	570	572
Related	568	562	572	562
Diff.	12	18	-2	10

for the related conditions, there was no difference between the no-study and study conditions (565 and 567 msec, respectively, collapsed across dominance). For the unrelated conditions, there was a _decrease_ in response time from the no-study, unrelated condition (580 msec) to the study, unrelated condition (571 msec); however, the 9 msec difference was only marginal by _a posteriori_ test, $F(1,329) = 3.42$, $MS_{e(res)} = 568.30$, $p < .08$.

The pronunciation data are consistent with two of three expectations based on the results of Experiment 5b. First, there was a clear reduction in priming with prior study of homographic primers: Facilitation obtained in the no-study condition, independent of the target dominance, whereas facilitation did not obtain for the study condition. Second, the lack of facilitation in the study condition appeared to be the result of a reduction in response times to _unrelated_ targets, although the effect was statistically weak; responses to related targets were not affected by the study manipulation, as was the case in Experiment 5b. The unexpected result was that dominance at study, which was a critical variable in the reduction of priming in the lexical-decision experiment, was not important in the present experiment.

The pronunciation data corroborate the findings of Experiment 5b, although there seem to be important differences between the context effect in the two tasks. Both experiments show that the distributed facilitation at short SOAs that has been taken to indicate that multiple meanings are initially accessed independent of context is subject to contextual manipulation. Furthermore, the way in which context exerted its effect - by shifting a baseline - opens up the question of the interpretation of differences between experimental and baseline conditions using short SOAs.

Cued recall

The recall results of the no-study condition in the present experiment can be compared to those of Experiments 1 and 2 (Tables 5 and 6), and the recall results of the study condition can be compared to the findings of the lexical-decision experiments. For Experiments 1 and 2 it was asked whether there would be an attenuation of the dominance effect from a long to a short SOA. Those results did show a small, unreliable attenuation, but it was observed in both experiments. The no-study condition of the present experiment is similar to Experiments 1 and 2, and therefore can be taken as another test of Koriat's (1981) view that at short SOAs a homograph is subject to a selective effect from the associated target. A replication of findings would therefore include showing no dominance effect, particularly for homographic cues versus associate cues. The relevant comparison for the study group, on the other hand, would be

Experiments 5b and 5c. For recall from the lexical-decision phase of those experiments, the dominance effect was replaced by a context effect for associated cues in Experiment 5b and for both homographic and associated cues in Experiment 5c.

Recall from pronunciation phase. Analyses were conducted on the proportion of correct responses out of a possible six. The mean proportions correctly recalled for related and unrelated pairs from the pronunciation phase are presented in Table 23. Only analyses of related pair members is reported; nothing of interest emerged for the unrelated pair members.

A repeated-measures analysis of variance, with study, test dominance, and cue type as variables, indicated only a single reliable effect: Dominant pair members were better recalled than subordinate pair members (.20 vs. .13), $F(1,47) = 12.08$, $MS_e = 0.034$. As in other experiments, there was some indication that the dominance effect was attenuated in the no-study condition if the homograph was the cue (.16 and .18, for subordinate and dominant pairs, respectively), but the three-way interaction of study, dominance, and cue type was not reliable, $F(1,47) = 2.64$, $MS_e = 0.02$, $p < .10$. (All other Fs < 1.4.)

Recall from study phase. The results for recall of associates from the study phase, given studied homographs as cues, are presented in Table 24. All studied homograph-

Table 23

Mean proportions of homographic primers (HOMOG) and associated targets (ASSOC) correctly recalled from the pronunciation phase, given the pair member as a cue, for conditions in Experiment 6. (Parenthesized values are proportions misattributed to the study phase of the experiment, and are included in the overall proportions correctly recalled.)

	cue	TARGET	Pair Type in Lexical Decision: UNREL'D	RELATED: Subordinate	Dominant	Diff.
NO-STUDY	homog	ASSOC	.03	.16 (.03)	.18 (.04)	.02
	assoc	HOMOG	.03	.13 (.03)	.22 (.03)	.09
STUDY	homog	ASSOC	.01	.10 (.00)	.19 (.03)	.09
	assoc	HOMOG	.04	.14 (.04)	.20 (.05)	.06

Table 24

Proportion of associates correctly recalled from the study phase, given the homograph as a cue, as a function of the type of intervening pronunciation trial between study and recall, for Experiment 6. Note: Intervening related trials were always of opposite dominance to study dominance.

Associate at study	Intervening pronunciation trial: Unrelated	Related
Subordinate	.42	.39
Dominant	.50	.51

associate pairs were followed by a either an unrelated or related pronunciation trial, and if the pairing was related, the dominance was the opposite of that studied. The analysis included study dominance (with test dominance as an implicit variable) and relatedness as variables. Repeated-measures analysis of variance indicated that only the main effect of dominance was reliable, $F(1,47) = 10.35$, $MS_e = 0.044$: Dominant associates were better recalled than subordinate associates (.505 vs. .405). All other Fs < 1.0.

This result replicates the findings of Experiments 5b and 5c in which the homograph was a better cue for a dominant associate than a subordinate associate. Interestingly, this result obtained despite the fact that the number of studied pairs in the present experiment was only half (48) that of the lexical-decision experiments. Once again, there appears to be a dominant bias in the cue-value of a homograph.

General Discussion

The purpose of Experiments 5 and 6 was to assess the effect of prior study of homographs on their subsequent influence as short-SOA primers. Specifically, it was asked whether *selecting* the meaning of a homograph in a study phase influences accessing operations in its subsequent processing as a primer. The results of the experiments will be summarized, first for response times, then for cued recall.

Response times

Consider the lexical-decision and pronunciation response times for Experiments 5a, 5b, 5c, and 6. The no-study groups of Experiment 5a (284- and 1500-msec SOAs) demonstrated that homographic primers seen for the first time in an experiment facilitate responses to both subordinate and dominant associates if the SOA is 284 msec, but facilitate responses to only dominant associates if the SOA is 1500 msec. This result established the appropriate baseline effect using a short SOA, and also replicated Experiments 1 and 2 using a different task. The sentence context manipulation of Experiment 5a did not change the conclusion for the short SOA: Facilitation obtained for both subordinate and dominant associates, whether the studied meaning was congruous or incongruous with the tested meaning.

Paired-associate study in Experiment 5b did show a context effect. If a homograph was first studied with a subordinate associate, facilitation in the lexical-decision task was eliminated for both dominant and subordinate associates. In contrast, faster times to respond to subordinate and dominant associates, compared to unrelated baselines, still obtained if the dominant meaning was studied. Importantly, the elimination of the difference between related and unrelated conditions was the result of a reduction in the amount of time to respond to unrelated targets. Experiment 5c, however, showed that this context effect could itself be eliminated if the SOA was reduced from 284 msec to 184 msec, re-instating "facilitation" for both subordinate and dominant associates, regardless of which meaning was studied.

Experiment 6 also showed an effect of prior study on unrelated baselines in a different task, pronunciation. The experiment demonstrated within subjects that unstudied homographs "facilitate" responses to both subordinate and dominant associates, whereas homographs studied with either subordinate or dominant associates eliminate "facilitation" by reducing time to respond to unrelated words.

Cued recall

The no-study groups of Experiment 5a provided further evidence that encoding of a homographic primer and associated target is different if the SOA is short (284 msec) than if it is long (1500 msec). Generally, for the long SOA there was an advantage for recall of members of dominant pairings, whereas for the short SOA this advantage was attenuated, albeit not statistically reliably, but replicably (see Experiments 1, 2, 5a (no-study groups), and 6 (no-study condition)). The attenuation of the dominance effect using a short SOA is consistent with Koriat's (1981) view that at a short SOA a homographic primer is encoded in terms of the contiguous associate, whether it be a subordinate or dominant associate. For the sentence-study group of Experiment 5a, evidence was sought that contextual bias was induced by first studying the homographs. However, there was no indication that the normally strong effect of dominance was replaced by a context effect: Recall of pair members from the lexical-decision phase was consistently in favour of the dominant meaning. Experiment 5b, which used paired-associate study, did produce evidence for a context effect in recall: For the lexical-decision phase, recall of homographs cued by associates was best if study pairs and lexical-decision pairs were congruous in meaning. Nonetheless, if the cues were homographs, recall was consistently biased in favour of dominant associates, a bias that was also present for recall of studied associates. By using a shorter SOA (184 msec) in Experiment 5c, the advantage in recall of dominant associates given homographic cues was eliminated for recall from the lexical-decision phase, but recall from the study phase still favoured dominant associates. Experiment 6 failed to replicate the biasing effect of prior study on episodic memory for pair members in the response-time task; only the effect of dominance was reliable. Recall from the study phase again demonstrated that there is a dominance bias in the cue-value of a homograph, even if it has been studied with a subordinate associate.

Episodic influence in semantic tasks

Prior experiments have shown that processing of a stimulus can be substantially altered on its second presentation in an experiment (e.g., Jacoby, 1983; McKoon & Radcliff, 1979; Monsell, 1978; Rabbit & Vyas, 1973). Experiments 5 and 6 used initial study of homographs as a means of influencing their processing as primers. There are differing views about the cognitive basis of the repetition effect. One view is that basic perceptual processing is altered, that a repeated stimulus is perceived differently (Jacoby, 1983; Jacoby & Dallas, 1981). In the present context, this amounts to the claim that memorial accessing operations can be influenced by prior selective operations. Another view (e.g., Forster & Davis, 1984) is that perceptual analysis proceeds in the same way for a repeated stimulus (access to memorial information is unaltered), but that post-access, inferential processes are altered for repeated stimuli (see also Oliphant, 1983).

These issues will not be discussed in depth here. However, ignoring for the moment the methodological, baseline issue raised by Experiments 5 and 6, if the results for the 284-msec, no-study condition of Experiment 5a are compared to the 284-msec, study condition of Experiment 5b, there is no doubt that prior study of homographic primers reduced, under some conditions, the distributed "facilitation" taken to be indicative of accessing operations. But Experiment 5c showed that the distributed "facilitation" characteristic of accessing operations can be reinstated by using a shorter SOA

(184 msec). This finding is, as it stands, more consistent with lexical access that is independent of context. But Experiment 6, which used a pronunciation task and an SOA of 184 msec, found a context effect similar to Experiment 5b, so it would be premature to argue that accessing operations cannot be influenced by prior study.

<u>Facilitation at short SOAs</u>?

What really requires some account in Experiments 5 and 6 is why the locus of the context effect was in the unrelated conditions. What account can be given? There is no easy explanation, but one possible account is that a difference between related and unrelated conditions using a short SOA is caused by a relative slowing of responses to unrelated words rather than a relative speeding of responses to related words, and that there are conditions (some found in the experiments) that antagonize this inhibition. As such, a short SOA between a primer and a target would represent an interference condition that is maximized for unrelated pairings rather than a facilitative condition that is maximized for related pairings. On this account, the pattern of facilitation for short and long SOAs would still be different - as many experiments have shown, but for different reasons than posited by the two-factor theory. The two-factor theory attributes differences between related and unrelated conditions at short SOAs to <u>activation</u> of semantically related representations in the related case compared to no activation in the unrelated case. At long SOAs, the two-factor theory attributes facilitation to the attentional system (expectation), not automatic activation, although depending on the SOA, there can be a combination of the two (Neely, 1977). On the present view, the two-factor account of effects at the long SOAs would remain intact. But at short SOAs, a general pattern of interference would characterize all word-word trials, with the additional assumption that the amount of response interference as a function of decreasing SOA would increase more sharply for unrelated pairings than related pairings.

Evidence for the general inhibition of responses in word-word trials using short SOAs comes from a number of sources, primarily using the pronunciation task. Rossmeissl (Note 2) found that latencies to pronounce a target word were inhibited if the target was simultaneously, laterally flanked by words compared to Xs, with less inhibition for related words than unrelated words. The inhibition was task dependent because he did not find comparable effects if the task was semantic categorization. Maxwell (1981) also found comparable inhibition for all word-word trials relative to XXXXX-word trials in a pronunciation task. The task was similar to that employed in the present experiments, except that two primers were presented before the target word. The conditions of interest were either of the form word-word-word or XXXXX-XXXXX-word. The finding was that, at 100-msec SOA from the second (middle) primer to the target, all word-word-word trials were inhibited relative to XXXXX-XXXXX-word trials, and the inhibition declined linearly as a function of increasing SOA, disappearing almost entirely at the longest SOA (100, 200, and 500 msec SOAs). Importantly, the related-word conditions were consistently inhibited less than the unrelated-word conditions, so that there was an appearance of "facilitation" if only word conditions were compared. There is also evidence for such inhibition from unrelated words in a perceptual identification task (Allport, 1977).

Assuming that such an account in terms of general word-word inhibition at short SOAs is plausible, some explanation would still be necessary of (1) the origin of this inhibition, (2) why relatedness of words antagonizes it without appealing to automatic activation, as well as (3) release from inhibition to accomodate the findings for the unrelated conditions in Experiments 5 and 6. The exact details of such an account are not clear at the present time. The first experimental tactic in testing the account would be to identify the incongruous semantics of unrelated word pairs as inhibitory. To do this, at least one additional baseline condition would be needed to compare with the related and unrelated conditions. Pronounceable non-words could be used as primers for word targets; they would have all the characteristics of word primers except lexicality. If there is no real "facilitation" in the related condition, only inhibition in the unrelated, and semantic incongruity is the origin of the inhibition, then at short SOAs response times to words primed by non-words and related words should be identical, both being greater than for words primed by unrelated words. Of course, this pattern would be expected to change as the SOA was increased, progressively conforming to the more standard priming effects found using long SOAs.

The findings of the present experiments that any account would need to accomodate are the following. Prior study of a homographic primer influenced responses to unrelated words, not related words, in both lexical decision and pronunciation. Performance in lexical decision and pronunciation is affected somewhat differently. In lexical decision, subordinate study mediated the effect, and it obtained only at 284-msec SOA, not 184-msec SOA. In pronunciation, both subordinate and dominant study mediated the effect, and it obtained, unlike for lexical-decision, at 184-msec SOA (no test at a shorter SOA was conducted using pronunciation). All things considered, it would seem that the effect of context is some joint function of relatedness at test, dominance at study, and type of task.

Whatever the explanation for the effect of context in the foregoing experiments, for present purposes the implication is that evidence taken to support initial access of multiple meanings independently of context has been called into question; at the very least, the interpretation of priming effects at short SOAs as support for multiple access must be qualified. The failure to find semantic priming at short SOAs has just recently come to light as a phenomenon in the priming literature using both lexical decision (Neely & Durgunoglu, 1985) and digit naming (Flowers, Nelson, Carson, & Larsen, 1984). Neely and Durgunoglu (1985) were studying the effects of prior study of pairs of words on priming in both episodic recognition and lexical decision. Their priming conditions in the "test" (response time) phase of the experiments included various combinations of studied and unstudied primers and targets, as well as related and unrelated words. In one of their conditions, neither the primers nor targets had been studied, and the words were either semantically related or unrelated. The usual finding using a short SOA is that response times to make lexical decisions are faster in related-word conditions than unrelated-word conditions, independent of the expectations of subjects (e.g., Favreau & Segalowitz, 1983; Neely, 1977). The standard interpretation of this effect is that facilitation using short SOAs is "automatic". However, Neely and Durgunoglu (1985) failed to find facilitation in precisely the condition in which it should have occurred according to the two-factor theory (Posner & Snyder, 1975). They commented (p. 482): "Such a finding indicates that automatic facilitatory semantic priming effects in the lexical decision task may not be as easily obtained as the term 'automatic' implies they should be...."

The failure to find semantic priming under some conditions is not a phenomenon which is understood at this time. Neely and Durgunolgu (1985) were unable to account for their result, and McKoon and Ratcliff (1986, p. 114), commenting on Neely and Durgunoglu's result, said "Why Neely and Durgunoglu (1985) did not obtain semantic priming is a question for which we have not been able to think of a convincing answer." McKoon and Ratcliff (1986, p. 114) concluded, as did Neely and Durgunoglu, that "...the possibility must be considered in future research that fast automatic activation depends on appropriate processing of the prime or on strategies that can be manipulated by experimental procedures."

Experiments 5 and 6 have raised a number of questions about evidence taken to confirm exhaustive access to the meanings of homographs: priming effects at short SOAs. Although it is clear that there are replicable differences between related and unrelated conditions at both short and long SOAs, it is not clear what is the proper account of the differences at short SOAs. The origin of the effects is not well understood. Future experiments will need to pay special attention to baselines, and entertain the possibility that there is a dynamic relation between baseline conditions and experimental conditions as a function of the temporal contiguity between primer and target.

Chapter 6

SUMMARY AND CONCLUSION

> Homonymy is not a force working inevitably, inescapably, destroying mercilessly everything that a blind phonetics delivers to it: it will come into play only if there is an encounter, and such an encounter will arise only in the case of words belonging to the same paths of thought.
>
> Gilleron-Roques (Quoted in Ullman, 1970, p. 182)

Considered out of context, a homograph is a local semantic uncertainty in an utterance, a fact that defines the phenomenon of lexical ambiguity. Various kinds of information are potentially useful for reducing semantic uncertainty, including lexical structure and both syntactic context and semantic context. But memory theorists differ about how this information is used. At one extreme, disambiguating information is taken to interact prior to the occurrence of a homograph to constrain memorial access to only a contextually congruous meaning; as such, there is no local semantic uncertainty associated with a homograph. At the other extreme, there is always initial semantic uncertainty, regardless of context, because some retrieval processes are taken to be independent of context. These retrieval processes are often described as "internal" to the mental lexicon because their operation is "encapsulated" (Fodor, 1983) within a lexical system. One kind of context-independent view posits exhaustive access to the meanings of a homograph, prior to the selection of either the dominant meaning (in the absence of context) or the contextually appropriate meaning. The exhaustive access view posits that the only information used for accessing meaning in the mental lexicon is the spelling pattern of a word. All meanings associated with that pattern are initially accessed, and a single meaning is selected by a post-access process on the basis of evidence favouring one meaning. An ordered-search view modifies this extreme view of access to the mental lexicon by specifying that the semantic content of the lexicon is structured according to the amount of prior experience with meanings, the latter factor being operationalized as frequency of meaning in the language (meaning dominance). Meanings are accessed according to their frequency of occurrence, beginning with the high-frequent meaning, which is then submitted to a decision process external to the lexicon proper. The decision process either accepts the submitted entry as consistent with contextual information, thereby terminating access operations, or rejects the submitted entry and accesses the next-most frequent meaning.

The experiments focused on one source of evidence for exhaustive access using procedures which examine the resolution of ambiguity over time. Experiments 1 and 2 demonstrated that a homographic primer facilitates speed of pronunciation of both dominant and subordinate associates if the SOA is short, and facilitates speed of pronunciation of only the dominant associate if the SOA is long. This basic finding, which replicates Onifer and Swinney (1981), is consistent with the claim that more than one meaning is accessed and that meaning dominance is a factor related to selection, not to initial access. However, such a finding is also consistent with selective access if at short SOAs the target exerts a selective influence on the homographic primer (Koriat, 1981). This proposal was tested by assessing the degree of memorial bias induced by the short and long SOA "study" conditions in cued recall. The hypothesis was that, whereas there should be a dominant bias if the SOA at study is long because the dominant meaning is selected, there should be a bias toward the target meaning if the SOA is short because the meaning specified by the target is selected. There was some support for this hypothesis because the dominant bias was attenuated for the short-SOA condition, but it was statistically weak. Because the dominance effect in cued recall was never entirely eliminated in the short-SOA condition, it was concluded that facilitation at short SOAs is evidence for accessing operations, not selective operations. Although exhaustive access passed the tests provided by Experiment 1 and 2, the cued-recall data lent some plausibility to the idea that a selective process is operating at short SOAs.

The exhaustive-access view has received a major impetus from experiments that use homographs as primers and vary their processing time before a rapid response is required to targets of various kinds. However, no experiments have tested exhaustive access by measuring responses to homographs themselves, yet on this view multiple meanings must necessarily be accessed in the course of responding to a homograph. Experiments 3 and 4 sought to test exhaustive access by using a priming procedure in which the homograph is a target requiring a response, instead of a primer not requiring a response. As part of the rationale for the experiments, it was noted that there is a bias to pronounce the dominant meaning of a homograph (Carpenter & Daneman, 1981), which means that the dominant meaning is selected. Given that subordinate meanings must also be accessed prior to the dominant meaning being selected, a rationale based on Stroop-like interference was developed about the pattern of response times to homographs primed by associates. It was hypothesized that at short SOAs a subordinate primer should interfere with time to pronounce a homograph, whereas a dominant primer should facilitate time to pronounce a homograph. Furthermore, this effect was expected to be limited to short SOAs. At a long SOA, facilitation was predicted for both subordinate and dominant conditions, although it was unclear how much the single-word contexts would offset the tendency to select the dominant meaning of the homograph. Experiment 4 confirmed the critical predictions for the short SOA: Subordinate primers inhibited pronunciation of the homograph, whereas dominant primers facilitated pronunciation of the homograph. For the long SOA, there was very small, unreliable facilitation for both the subordinate and dominant conditions, although this small facilitation was obtained in two experiments. It was argued that neither selective nor ordered access could account for the pattern of pronunciation times across SOAs. The result for the short SOA also disconfirmed what would be expected on the basis of Koriat's (1981) view that a temporally-contiguous associated word selectively primes only one meaning of a homograph. On this view, facilitation should have obtained for both the subordinate and dominant conditions at a short SOA. Finally, although response times indicated that processing was different as a function of SOA, cued recall did not reflect this, showing a consistent dominance effect.

Together, the results of the first four experiments favour exhaustive access. Nonetheless, whether exhaustive access is the correct account of homograph processing depends on how immune the hypothetical accessing operations are to manipulations of context. If facilitation of response time at short SOAs reflects a context-independent retrieval process, then this facilitation should obtain regardless of prior encoding operations on homographic primers.

To test the hypothesis of contextual independence, homographs were first studied in either their subordinate or dominant senses, and then used as primers in a subsequent response-time task, either lexical decision (Experiments 5a, 5b, 5c) or pronunciation (Experiment 6). The important result of Experiments 5 and 6 was that prior study of homographic primers can, under certain conditions, eliminate facilitation at short SOAs in both lexical decision and pronunciation. The elimination of facilitation was, however, accomplished in a curious way: Times to respond to unrelated words in the baseline condition were reduced to the same level as in the related conditions. Furthermore, there were important differences in the effect of context for lexical decision and pronunciation. For lexical decision, the reduction in time to respond to unrelated words obtained only if the subordinate meaning was studied, and the pattern of "facilitation" for both subordinate and dominant conditions at a short SOA was re-instated if the SOA was shortened from 284 msec to 184 msec. For pronunciation (Experiment 6), a reduction in time to respond to unrelated words obtained if either the subordinate or dominant meaning was studied, and this reduction occurred, unlike in lexical decision, with an SOA of 184 msec.

It was argued on the basis of the response-time data that priming at short SOAs is, under some conditions, subject to selective effects, but that the parameters of priming at short SOAs are poorly understood. It was hypothesized that differences at short SOAs may be a function of inhibition in trials in which the primers and targets are semantically unrelated, rather than facilitation in trials that are related, although such an account of "facilitation" at short SOAs would require further research examining the baseline issue. Be that as it may, it would still be premature to argue that the difference between both subordinate and dominant conditions and unrelated control conditions at short SOAs unequivocally indicates accessing, as opposed to selective, operations. By thus casting doubt on one of the principal empirical supports for exhaustive access, indeed, on one of the principal theoretical constructs of the two-factor theory of attention, namely automatic, capacity-free activation, the notion of exhaustive access as the processing rule in the resolution of lexical ambiguity cannot be maintained in its present form.

The cued-recall data also raised some interesting questions. One concern that motivated the use of an episodic measure in the experiments was whether the encoding processes hypothesized to be operating in the response-time tasks would also be reflected in episodic memory. The main hypothesis based on exhaustive access was that, to the extent that response time in priming tasks is interpreted in terms of contextually-independent processes, there should be no evidence in memory performance that contextually-specific processing has occurred. The critical comparison for this hypothesis was between cued recall in those conditions of "study" involving only contextually-independent access (short SOAs) and cued recall in those conditions of "study" involving selection (long SOAs). Specifically, in the "no-context" experiments (Experiments 1 and 2), and the "no-context" conditions of other experiments (Experiment 5a and 6), evidence was sought for some attenuation of the dominance effect at short SOAs that is charactertistic of long SOAs. If the results of any one experiment are considered, then there was typically some statistically unreliable attenuation of the dominance effect. If all the experiments are considered, there was small but replicable attenuation of the dominance effect. In the context conditions of experiments in which subjects studied one or another meaning of a homograph prior to the response-time task (Experiments 5a, 5b, 5c, and 6), there was also evidence that recall of pair members from the response-time phases - in which contextually-independent processes were hypothesized to be operating at short SOAs - could be influenced. Together, the recall results show that selection factors can have a small, but consistent, effect on conditions of presentation taken to indicate contextually-independent processing.

Conclusion

The central psychological distinction motivating the experiments was that between memorial processes that initially access a set of information and those that select from the accessed set to produce a semantically determinate outcome. Interest was focused on the view that this is a rule in the perceptual processing of lexical ambiguities. The distinction between accessing and selecting has a certain appeal on logical grounds, based on the idea that the instantiation of a concept entails some categorical knowledge about what the instance is an instance of. (For example, one could not know something about "humans" without also knowing something about "living things"; for criticism of this view, and a defense of an alternative, see Dretske, 1982.) But such a distinction between memory processes can be sustained as the processing rule only if it is assumed that our cognitive system is always in some indeterminate state. It has been suggested that the critical test of this processing rule is to first put the cognitive system into some determinate state and then apply the test for accessing operations. The outcome of this manipulation in the context experiments showed that there are exceptions, although the exact nature of these exceptions is not clearly understood at this time. Both methodological and substantive issues stand in need of clarification.

The experiments highlight a shortcoming of research strategies on the resolution of lexical ambiguity, as for other areas: The most extreme boundary conditions have often not been explored as a means of defining the parameters of the phenomenon. Experimental test cases that could falsify our most extreme claims have not been systematically explored. The exhaustive-access model is an extreme one that demands extreme test cases. Imagine, for example, that if accessing operations were contextually invariant, having just resolved a lexical ambiguity would entail that the same accessing routines would be operative in the very next instant after resolution! Surely interpretations must remain stable for sufficiently long to allow integration, over time, with other semantic information consistent with it. Coherent interpretative strategies could not be maintained otherwise.

An alternative point of departure for research on lexical ambiguity would include asking the question: How long does semantic certainty (a resolved ambiguity) remain that way, and under what conditions is there likely to be a return to a state of uncertainty? This question is really implicit in the whole issue of ambiguity resolution, and yet, that it has not been asked reveals an assumption that perceptual analysis always proceed from the general to the specific, the abstract to the concrete, or the universal to the particular, instead of the other way around. Some recent trends in cognitive research and theory (see, for example, Jacoby & Brooks, 1984) indicate that an imbalance is being corrected, and such a correction will be central to answering the question of how context can come to have such a constraining effect, normally leaving us totally unaware of the ambiguity of words.

REFERENCE NOTES

1. Maxwell, D. R. Episodic factors in semantic priming. Progress Report, Department of Psychology, McMaster University, Hamilton, Ontario, April, 1982

2. Rossmeissel, P. G. Semantic processing of unattended visual words. Paper presented at the annual meeting of the Psychonomic Society, St. Louis, November, 1980.

REFERENCES

Allport, G. A. On knowing the meaning of words we are unable to report: The effects of visual masking. In S. Dornic (Ed.), Attention and performance VI. Hillsdale, N. J.: Erlbaum, 1977.

Balota, D.A. Automatic semantic activation and episodic memory encoding. Journal of Verbal Learning and Verbal Behavior, 1983, 22, 88-104.

Becker, C. A. Semantic context effects in visual word recognition: An analysis of semantic strategies. Memory & Cognition, 1980, 8, 493-512.

Cairns, H. S., & Kamerman, J. Lexical information processing during sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 1975, 14, 170-179.

Cairns, H. S., & Hsu, J. R. Effects of prior context upon lexical access during sentence comprehension: A replication and interpretation. Journal of Psycholinguistic Research, 1980, 9, 1-8.

Carpenter, P.A., & Daneman, M. Lexical retrieval and error recovery in reading: A model based on eye fixations. Journal of Verbal Learning and Verbal Behavior, 1981, 10, 137-160.

Carroll, M., & Kirsner, K. Context and repetition effects in lexical and recognition memory. Journal of Verbal Learning and Verbal Behavior, 1982, 21, 55-69.

Clark, H. H., & Gerrig, R. J. Understanding old words with new meanings. Journal of Verbal Learning and Verbal Behavior, 1983, 22, 591-608.

Conrad, C. Context effects in sentence comprehension: A study of the subjective lexicon. Memory & Cognition, 1974, 2, 130-138.

DeGroot, A. M. B. Primed lexical decision: Combined effects of proportion of related prime target pairs and the stimulus onset asynchrony. Quarterly Journal of Psychology, 1984, 36A, 253-280.

Deutsch, J. A., & Deutsch, D. Attention: some theoretical considerations. Psychological Review, 1963, 70, 80-90.

Dretske, F. Knowledge and the flow of information. Cambridge, Mass.: The MIT Press, 1982.

Dyer, F. N. The duration of word meaning responses: Stroop interference for different preexposures of a word. Psychonomic Science, 1971, 25, 229-231.

Dyer, F. N. The Stroop phenomenon and its use in the study of perceptual, cognitive, and response processes. Memory & Cognition, 1973, 1, 106-120.

Favreau, M., & Segalowitz, N. S. Automatic and controlled processes in the first- and second-language reading of fluent bilinguals. Memory & Cognition, 1983, 11, 565-574.

Feustal, T. C., Shiffrin, R. M., & Salasoo, A. Episodica dn lexical contributions to the repetition effect in word recognition. Journal of Experimental Psychology: General, 1983, 112, 309-346.

Flowers, J. H. "Sensory" interference in the word-colour matching task. Perception and Psychophysics, 1975, 18, 37-43.

Flowers, J. H., Nelson, S. M., Carson, D., & Larsen, L. Automatic and expectancy-based priming effects in a digit-naming task. Journal of Experimental Psychology: Human Perception and Performance, 1984, 10, 65-74.

Fodor, J. A. The modularity of mind. Cambridge, Mass.: MIT Press, 1983.

Fodor, J. A., Bever, T. G., and Garrett, M. F. The psychology of language: An introduction to psycholinguistics and generative grammar. New York: McGraw Hill, 1974.

Forster, K. I. Levels of processing and the structure of the language processor. In W. E. Cooper & E. Walker (Eds.), Sentence processing: Psycholinguistic studies presented to Merrill Garrett. Hillsdale: Erlbaum, 1979.

Forster, K. I. Priming and the effects of sentence contexts on naming time: Evidence for autonomous lexical processing. Quarterly Journal of Experimental Psychology, 1981, 33, 465-495.

Forster, K. I., & Bednall, E. S. Terminating and exhaustive search in lexical access. Memory & Cognition, 1976, 4, 53-61.

Forster, K. I., & Chambers, S. M. Lexical access and naming time. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 627-635.

Forster, K. I., & Davis, C. Repitition priming and frequency attenuation in lexical access. Journal of Experimental Psychology: Learning, Memory, and Cognition, 1985, 10, 680-698.

Foss, D. J. Some effects of ambiguity upon sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 699-706.

Foss, D. J., & Jenkins, C. M. Some effects of context on the comprehension of ambiguous sentences. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 577-589.

Hogoboam, T. W., & Perfetti, C. Lexical ambiguity and sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 1975, 10, 265-274.

Gumenik, W. E., & Glass, R. Effects of reducing the readability of words in the Stroop color-word test. Psychonomic Science, 1970, 20, 247-248.

Hogoboam, T. W., & Perfetti, C. A. Lexical ambiguity and sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 1975, 14, 265-274.

Holley-Wilcox, P., & Blank, M. A. Evidence for multiple access in the processing of isolated words. Journal of Experimental Psychology: Human Perception and Performance, 1980, 6, 75-84.

Holmes, V. M. Accessing ambiguous words during sentence comprehension. Quarterly Journal of Experimental Psychology, 1979, 31, 569-589.

Holmes, V. M., Arwas, R., & Garrett, M.F. Prior context and perception of lexically-ambiguous sentences. Memory & Cognition, 1977, 6, 103-110.

Jacoby, L. L. Perceptual enhancement: Persistent effects of an experience. Journal of Experimental Psychology: Learning, Memory, and Cognition, 1983, 9, 21-38.

Jacoby, L. L., & Brooks, L. R. Nonanalytic cognition: Memory, perception, and concept learning. In G. H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory. Volume 18. New York: Academic Press, 1984.

Jacoby, L. L., & Dallas, M. On the relationship between autobiographical memory and perceptual learning. Journal of Experimental Psychology: General, 1981, 3, 306-340.

James, C. T. The role of semantic information in lexical decisions. Journal of Experimental Psychology: Human Perception and Performance, 1975, 104, 130-136.

James, W. The principles of psychology. New York: Dover Publications, 1950.

Jastrezemski, J. E. Multiple meanings, number of related meanings, frequency of occurrence, and the lexicon. Cognitive Psychology, 1981, 13, 278-305.

Jensen, A. R., & Rohwer, W. D., Jr. The Stroop colour-word test: A review. Acta Psychologica, 1966, 25, 36-93.

Johnson-Laird, P. N. Mental models. Cambridge: Cambridge University Press, 1983.

Katz, J. J., & Fodor, J. The structure of semantic theory. Language, 1963, 39, 170-210.

Kausler, D. H., & Kollasch, S. F. Word associations to homographs. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 444-449.

Kiger, J. I., & Glass, A. L. The facilitation of lexical decisions by a prime occurring after the target. Memory & Cognition, 1983, 11, 356-365.

Kintsch, W. Semantic memory: A tutorial. In R. S. Nickerson (Ed.), Attention and performance VIII. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

Kintsch, W., & Mross, E. F. Context effects in word identification. Journal of Memory and Language, 1985, 24, 336-349.

Kirsner, K., & Smith, M. C. Modality effects in word recognition. Memory & Cognition, 1974, 2, 637-640.

Koriat, A. Semantic facilitation in lexical decisions as a function of prime-target association. Memory & Cognition, 1981, 9, 587-598.

Light, L. L., & Carter-Sobell, L. Effects of changed semantic context on recognition memory, Journal of Verbal Learning and Verbal Behavior, 1970, 9, 1-11.

MacKay, D. G., & Bever, T. G. In search of ambiguity. Perception and Psychophysics, 1967, 2, 193-200.

Marcel, A. J. Conscious and unconsious perception: An approach to the relations between phenomenal experience and perceptual processes. Cognitive Psychology, 1983, 15, 238-300.

Maxwell, D. R. Semantic priming effects in lexical ambiguity resolution. Unpublished Masters thesis, Wilfrid Laurier University, 1981.

McKoon, G., & Radcliff, R. Priming in episodic and semantic memory. Journal of Verbal Learning and Verbal Behavior, 1979, 18, 463-480.

Mehler, J., Segui, J., & Carey, P. Tails of words: Monitoring ambiguity. Journal of Verbal Learning and Verbal Behavior, 1978, 17, 29-35.

Meyer, D. E., & Schvaneveldt, R. W. Meaning, memory structures, and mental processes. In C. N. Cofer (Ed.), The structure of human memory. San Francisco: Freeman, 1975.

Miller, G. A., & Johnson-Laird, P. N. Language and Perception. Cambridge, Mass.: Harvard University Press, 1976.

Miller, G. A. Semantic relations among words. In M. Halle, J. Bresnan, & G. A. Miller (Eds.), Linguistic theory and psychological reality. Cambridge: MIT Press, 1978.

Minsky, M. A framework for representing knowledge. In P. H. Winston (Ed.), The psychology of computer vision. New York: McGraw-Hill, 1975.

Monsell, S. Recency, immediate recognition memory and reaction time. Cognitive Psychology, 1978, 10, 465-501.

Morton, J. Interaction of information in word recognition. Pscyhological Review, 1969, 76, 165-178.

Morton, J. Word recogntion. In J. Morton & J. C. Marshall (Eds.), Psycholinguistics: 2. Structure and processes. 1979

Morton, J. Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, M. E. Wrolstal, and H. Bouma (Eds.), The processing of visible language. New York: Plenum, 1979.

Neely, J. H. Semantic priming and retrieval from lexical memory: Evidence for facilitory and inhibitory processes. Memory & Cognition, 1976, 4, 648-654.

Neely, J. H. Semantic priming and retrieval from lexical memory: The roles of inhibitionless spreading activation and limited-capacity processing. Journal of Experimental Psychology: General, 1977, 106, 226-254.

Neely, J. H., & Durgunoglu, A. Y. Dissociative episodic and semantic priming effects in episodic recognition and lexical decision tasks. Journal of Memory and Language, 1986, 24, 466-489.

Nelson, J. I., McEvoy, C. L., Walling, J. R., & Wheeler, J. W. The University of South Florida homograph norms. Behavior Research Methods and Instrumentation, 1980, 12, 16-37.

Neuman, J. E., & Dell, G. S. The phonological nature of phoneme monitoring: A critique of some ambiguity studies. Journal of Verbal Learning and Verbal Behavior, 1978, 17, 359-374.

Norman, D. A. Toward a theory of memory and attention. Psychological Review, 1968, 75, 522-536.

Oden, G. C., & Spira, J. L. Influence of context on the activation and selection of ambiguous word senses. Quarterly Journal of Experimental Psychology, 1983, 35, 51-64.

Oliphant, S. W. Repitition and recency effects in word recognition. Australian Journal of Psychology, 1983, 35, 393-403.

Olson, J. N., & MacKay, D. G. Completion and verification of ambiguous sentences. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 457-470.

Onifer, W., & Swinney, D. A. Accessing lexical ambiguities during sentence comprehension: Effects of frequency of meaning and contextual bias. Memory & Cognition, 1981, 9, 225-236.

Posner, M. I. Chronometric explorations of mind. Hillsdale, N. J.: Erlbaum, 1978.

Posner, M. I., & Boies, S. J. Components of attention. Psychological Review, 1971, 78, 391-408.

Posner, M. I., and Snyder, C. R. R. Facilitation and inhibition in the processing of signals. In P. M. A. Rabbitt (Ed.), Attention and performance V. London: Academic Press, 1975.

Rabbitt, P. M. A., & Vyas, S. What is repeated in the "repetition effect"? In S. Kornblum (Ed.), Attention and Performance IV. New York and London: Academic Press, 1973.

Reed, A. V. Microcomputer display timing: Problems and solutions. Behavioral Research Methods and Instrumentation, 1979, 11, 572-576.

Rubenstein, H., Garfield, L., & Millikan, J. A. Homographic entries in the internal lexicon. Journal of Verbal Learning and Verbal Beahvior, 1970, 9, 487-494.

Rubenstein, H., Lewis, S. S., & Rubenstein, M. A. Homographic entries in the internal lexicon: Effects of systematicity and relative frequency of meanings. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 57-62.

Scarborough, D. L., Cortese, C., & Scarborough, H. S. Frequency and repetition effects in lexical memory. Journal of Experimental Psychology: Human Perception and Performance, 1977, 3, 1-17.

Schank, R. C. Conceptual dependency: A theory of natural language understanding. Cognitive Psychology, 1972, 3, 552-631.

Schank, R. C., & Abelson, R. Scripts, plan, goals, and understanding. Hillsdale, N.J.: Erlbaum, 1977.

Schvaneveldt, R. W., Meyer, D. E., & Becker, C. A. Lexical ambiguity, semantic context, and visual word recognition. Journal of Experimental Psychology: Human Perception and Performance, 1976, 2, 243-256.

Seidenberg, M. S., Tanenhaus, M. K., Leiman, J. M., & Bienkowski, M. Automatic access of the meanings of ambiguous words in context: Some limitations of knowledge-based processing. Cognitive Psychology, 1982, 14, 489-537.

Simpson, G. B. Meaning dominance and semantic context in the processing of lexical ambiguity. Journal of Verbal Learning and Verbal Behavior, 1981, 20, 120-136.

Simpson, G. B. Lexical ambiguity and its role in models of word recognition. Psychological Bulletin, 1984, 96, 316-340.

Stroop, J. R. Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 1935, 18, 643-661.

Smith, E. E. Theories of semantic memory. In W. K. Estes (Ed.), Handbook of learning and cognitive processes (Vol. 6). Hillsdale, N.J.: Erlbaum, 1978.

Swinney, D. A. Lexical access during sentence comprehension: (Re)Consideration of context effects. Journal of Verbal Learning and Verabl Behavior, 1979, 18, 645-659.

Swinney, D. A., & Hakes, D. T. Effects of prior context upon lexical access during sentence comprehension. Journal of Verbal Learning and Verbal Behavior, 1976, 15, 681-689.

Tanenhaus, M. K., Leiman, J. M., & Seidenberg, M. K. Evidence for multiple stages in the processing of ambiguous words in syntactic context. Journal of Verbal Learning and Verbal Behavior, 1979, 18, 427-440.

Townsend, J. T. Issues and models concerning the processing of a finite number of inputs. In B. H. Kantowitz (Ed.), Human information processing: Tutorials in performance and cognition. Hillsdale, N. J.: Erlbaum, 1974

Tulving, E. Elements of episodic memory. New York: Oxford University Press, 1983.

Ullman, S. Semantics: An introduction to the science of meaning. Oxford: Basil Blackwell, 1972.

Warren, R. E. Stimulus encoding and memory. Journal of Experimental Psychology, 1972, 94, 90-100.

Warren, R. E. Association, directionality, and stimulus encoding. Journal of Experimental Psychology, 1974, 102, 151-158.

Warren, R. E., Warren, N. T., Green, J. P., & Bresnick, J. H. Multiple semantic encoding of homophones and homographs in contexts biasing dominant or subordinate meanings. Memory & Cognition, 1978, 6, 364-371.

Wickelgren, W. A. Human learning and memory. In M. R. Rosenzweig and L. W. Porter (Eds.), Annual review of Psychology, Vol. 32. Palo Alto, Cal.: Annual Reviews Inc., 1981.

Winograd, E., & Conn, C. P. Evidence from recognition memory for specific encoding of unmodified homographs. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 702-706.

Wollen, K. A., Cox, S. S., Coahran, M. M., Shea, D. S., & Kirby, R. F. Frequency of occurrence and concreteness ratings of homograph meanings. Behavior Research Methods and Instrumentation, 1980, 12, 8-15.

Appendix A. Homographs and Associates used in Experiment 1 and 2, listed by counterbalancing blocks.

Block	HOMOGRAPHS	Subordinate Associates	Dominant Associates
1	watch	look	time
	jar	bump	lid
	slide	film	skid
	count	add	duke
	prune	bush	juice
	type	sort	writer
	broke	poor	pieces
	pitch	voice	catch
	train	teach	tracks
	slip	garment	fall
	fly	insect	glide
	block	cement	tackle
2	roll	bun	over
	steer	car	cow
	hatch	cover	eggs
	vault	pole	safe
	stick	gum	branch
	grate	grill	cheese
	play	games	actor
	punch	drink	hit
	might	power	maybe
	duck	under	goose
	nag	pester	horse
	maroon	island	colour
3	shower	rain	soap
	lash	eye	whip
	sign	name	road
	pelt	hurl	fur
	hail	snow	chief
	dove	diver	pigeon
	shed	garage	skin
	spell	witch	words
	fling	lover	toss
	relish	enjoy	pickle
	bear	burden	woods
	digest	readers	stomach
4	sow	reap	pig
	figure	number	body
	stamp	feet	mail
	drop	down	drip
	ring	bell	diamond
	gag	joke	choke
	loaf	lazy	bread
	strand	beach	hair
	strip	bacon	naked
	boil	blister	cook
	fit	seizure	tight
	tap	faucet	fingers

Block	HOMOGRAPHS	Subordinate Associates	Dominant Associates
5	smelt	fish	ore
	tear	rip	cry
	bluff	high	fake
	bowl	pins	cereal
	strain	noodles	stress
	chuck	dump	steak
	strike	union	blast
	race	black	run
	ram	smash	sheep
	pound	beat	weight
	march	step	month
	drill	practice	cavity
6	tick	flea	tock
	chop	cut	meat
	shot	arm	gun
	stall	wait	cattle
	saw	see	hammer
	refrain	chorus	stop
	lean	slant	fat
	box	fight	square
	refuse	trash	reject
	swallow	throat	nest
	ground	coffee	earth
	row	column	paddle
7	smack	slap	lips
	match	fire	pair
	shift	work	gear
	peer	peek	group
	dart	dash	spear
	tire	weary	flat
	fuse	join	wire
	quiver	arrow	shake
	void	empty	toilet
	jerk	stupid	pull
	wake	wave	sleep
	hamper	prevent	laundry
8	bark	tree	dog
	lap	lick	sit
	sock	jaw	shoe
	press	news	push
	jam	door	jelly
	sink	swim	kitchen
	lead	guide	heavy
	change	alter	money
	fix	drugs	repair
	mug	assault	beer
	seal	letter	shark
	bug	bother	beetle

Appendix B. Homographs and Associates used in Experiment 3 and 4, listed by counterbalancing blocks.

Block	HOMOGRAPHS	Subordinate Associates	Dominant Associates
1	watch	observe	wrist
	jar	jolt	bottle
	slide	projector	slippery
	count	multiply	nobleman
	prune	trim	fruit
	type	category	secretary
	broke	penniless	shattered
	pitch	tone	baseball
	train	instruct	railroad
	slip	skirt	stumble
	fly	hornet	soar
	block	concrete	obstruct
2	roll	muffin	tumble
	steer	drive	bull
	hatch	submarine	hen
	vault	jump	bank
	stick	glue	stave
	grate	iron	grind
	play	children	drama
	punch	haiwaiian	boxing
	might	strength	possibly
	duck	dodge	swan
	nag	aggrevate	mare
	maroon	abandon	purple
3	shower	thunder	bathe
	lash	brows	flog
	sign	signature	highway
	pelt	cast	trapper
	hail	sleet	tribute
	dove	plunged	crow
	shed	storage	molt
	spell	trance	school
	fling	affair	propel
	relish	savour	mustard
	bear	support	grizzly
	digest	magazine	eat
4	sow	seeds	swine
	figure	calculate	shapely
	stamp	stomp	postage
	drop	descend	water
	ring	telephone	wedding
	gag	prank	vomit
	loaf	loiter	bake
	strand	shipwreck	dyed
	strip	slice	undress
	boil	ulcer	fry
	fit	epileptic	clothes
	tap	spigot	rap

Block	HOMOGRAPHS	Subordinate Associates	Dominant Associates
5	smelt	salmon	copper
	tear	shred	sorrow
	bluff	cliff	mislead
	bowl	alley	breakfast
	strain	seive	hardship
	chuck	discard	groundbeef
	strike	workers	bombard
	race	negro	sprint
	ram	battering	goat
	pound	thump	ounce
	march	military	february
	drill	exercise	dentist
6	tick	parasite	clock
	chop	hack	pork
	shot	injection	killed
	stall	delay	barn
	saw	perceived	tool
	refrain	song	cease
	lean	tilt	thin
	box	wrestle	crate
	refuse	garbage	decline
	swallow	gulp	bird
	ground	grinder	soil
	row	numbers	oars
7	smack	spank	kiss
	match	flame	compare
	shift	graveyard	move
	peer	peep	friend
	dart	scamper	weapon
	tire	fatigue	blowout
	fuse	blend	electrical
	quiver	archer	tremble
	void	space	urinate
	jerk	dummy	yank
	wake	boat	morning
	hamper	hinder	basket
8	bark	birch	growl
	lap	slurp	knee
	sock	whack	stocking
	press	reporter	squeeze
	jam	wedge	strawberry
	sink	float	basin
	lead	direct	metal
	change	modify	coins
	fix	heroin	mend
	mug	rob	jug
	seal	envelope	dolphin
	bug	irritate	roach

Appendix C. Homograph/non-word pairs used in Experiments 5a, b, c. (Note: Homograph/word pairs for the study phase are in Appendix B, and for the lexical-decision phase are in Appendix A.)

Primer Word	Non-word Target	Primer Word	Non-word Target
punish	pheat	median	abrate
sage	spide	tip	warfer
screen	wase	kind	motie
flat	gice	sense	cobbon
mad	sorker	range	ongry
staff	teft	can	nanch
afghan	swout	ruler	klank
cape	cing	rock	ceat
letter	tebble	mint	darlage
deck	coan	bass	shubble
toast	yerring	crank	gread
date	vern	limp	frouch
tablet	fracid	base	waper
chest	scote	chick	zody
grain	wamen	bridge	balt
fine	rixer	mean	fenal
trunk	enil	marble	dree
case	slatue	orderly	prote
orgain	gessy	bat	heast
tennis	dase	store	wernid
pupil	lave	hard	staden
blunt	moft	quack	pharp
second	goctar	rash	thard
staple	masty	board	doob
float	spim	major	manot
acid	appich	panel	debot
pitcher	slast	sling	brodel
tank	artour	bank	troit
file	clerm	compact	drave
glove	goot	pat	pab
stew	totch	temple	charck
cell	pload	club	zeadon
crane	nachin	trust	wund
interest	pibe	mine	yoops
vessel	shad	colon	vomme
pillar	lail	joint	elgor
speaker	sleret	gross	pude
charm	smole	cap	yat
deed	leat	book	swary
novel	rewer	pip	malm
still	tard	light	dilet
sole	cood	bean	asey
spade	beauky	grace	jench
top	foy	park	simmle
plain	deg	calf	bodant
rat	unid	rare	peate
dish	wost	present	labe
invalid	kale	yarn	dobby

Appendix D. Mean pronunciation times based on the subject-cell medians and ANOVA table for Experiment 6.

Mean pronunciation times based on the subject-cell medians and ANOVA table for Experiment 6.

	No-study		Study	
			Dom	Sub
Dominance at test	Sub	Dom	Sub	Dom
Unrelated	517	525	517	517
Related	513	512	516	509
Diff.	4	13	1	8

ANOVA Table

Source	ss	df	ms	F	p
Blocks/subjects	1722484	47			
Relatedness	4023	1	4203	10.34	.002
Error	19105	47	406		
Test Dominance	.09	1	.09	0.00	
Error	28038	47	596		
Rel X TDom	1550	1	1550	2.91	.09
Error	24956	47	530		
Study (no/yes)	401	1	401	1.05	.31
Error	17864	47	380		
Rel X Study	378	1	378	.87	
Error	20474	47	435		
Dom X Study	986	1	986	2.85	.094
Error	16247	47	345		
Rel X Dom X Study	4	1	4	0.01	
Error	19360	47	411		
Total	1876058	383			
(Residual)	146048	329			