THE ROLE OF INTERSENTENTIAL CONTEXT IN RESOLVING LEXICAL AMBIGUITY; IMPLICATIONS FOR CURRENT MODELS OF LEXICAL ACCESS AND LANGUAGE PROCESSING

Hassan A. Taman
Faculty of Education
Alexandria University

ABSTRACT

A list of 40 ambiguous Arabic words was presented to 200 native speakers of Arabic to find out the biased reading of each word. Ten words that exhibited response polarity, i.e. high degree of bias towards one meaning as opposed to the other(s) (>90%), were embedded in ten coherent episodes. Each episode represented one of eight possible textual conditions of disambiguation depending on the position of the ambiguous fragment, meaning bias, and the presence or absence of distancing text. Sentences in the parallel experimental conditions were constructed in such a way that they had the same number of words, the same number of morphemes and the same number of transformations, to control for ease or difficulty of comprehension. The episode types were rotated so that eight groups (data sets) equivalent in the number and types of experimental conditions were created. This was meant to control for any possible primacy effects or intergroup variance.

A BASIC program was written to present the data and to measure reading time in milliseconds. A sample of native speakers of Arabic (n=80) randomly assigned to eight groups (for the eight data sets) were tested individually in a self-paced reading-for-comprehension test through an IBM Compatible Microcomputer.

Results indicate that latency in reading for comprehension is higher in distant vs. immediate disambiguation, for non-biased vs. biased cases, and for retroactive vs. proactive disambiguation. These results tend emphasize the role of bias in activating higher level knowledge structures that guide the process of comprehension. The varying latencies are explained in terms of the reader's attempt to reconcile the maintained scenario with the conflicting information presented in the disambiguating fragment.

Results also show that resolving lexical ambiguity occurs within the framework of a scenario element based on the interaction of text input, text knowledge, and higher level knowledge. Incongruity between textual information and other textual or higher level information has adverse effects on latencies in the processing of language data. Implications for current models of lexical access and language processing are drawn, and a model is proposed on the basis of the experimental findings to explain the nature of interaction between higher and lower levels of information. The model incorporates the process of lexical access and knowledge access in a non-modular fashion, which makes it applicable in the domains of Artificial Intelligence (AI) and Natural Language Processing (NLP).

INTRODUCTION:

It is generally agreed that, in language comprehension, people are seldom conscious of lexical ambiguity and that on-line disambiguation is rather automatic and effortless. Evidence contradicting this commonsense conviction includes Hirst's (also commonsense) remark that contrary to puns and double entendres, which rely on making both meanings of an ambiguous word known to the listener, many jokes are based on leading listeners to perceive one meaning only at the beginning, and then to become aware of the other meaning later (Hirst, 1988). Raskin (1985) discusses the use of linguistic ambiguity in humor. Weiner & DePalma, (1993) describe a category of riddles based on lexical ambiguity, and use category theory to illustrate the function of the accessibility hierarchy in riddling. They relate riddles to parallelism (i.e. the tendency to stay on the same syntactic, semantic, and pragmatic track while processing language). Also, Mohanty (1983) found that the presentation of a lexically or structurally ambiguous sentence causes a significantly greater rise in the rate of a person's heartbeat compared to unambiguous sentences.

The aim of this paper is twofold; first, it aims to present a critical review of the various attempts in the psycholinguistic literature at characterizing the processing of lexical ambiguity, and how such attempts relate to the theory of language processing in general, and the theory of lexical access in particular. Second, it attempts to present a more plausible characterization of the processing of lexical ambiguity that takes into account the shortcomings of existing models and the role of intersentential context in the process of resolving lexical ambiguity. This characterization will be tested in an experimental framework, and relevant implications for the theory of language processing and lexical access will be drawn.

ASPECTS OF THE STUDY OF LEXICAL AMBIGUITY:

There are two aspects to the study of ambiguity; first, studying ambiguity in its own right with the aim of finding out how ambiguous sentences are actually processed, whether the different senses of an ambiguous word get activated simultaneously or consecutively, and the extent to which this affects the complexity (the difficulty) of the sentence. This first trend subdivides into two major directions, theoretical and practical; the theoretical direction has, more or less, the same objectives outlined above. The practical direction, on the other hand, is represented by researchers in the fields of Machine Translation (MT) and Artificial Intelligence (AI), who are plagued with the problem of ambiguity in their attempts at developing workable Natural Language Processing (NLP) systems.

The second aspect of the study of ambiguity does not deal with the various types of ambiguity in their own right. Rather, it involves the utilization of experimenting with ambiguous sentences in formulating hypotheses about the process of language comprehension. Obviously, the second aspect of the study of ambiguity is essentially more relevant, for the simple reason that if it is taken as a starting point, most of the questions raised in the study of ambiguity for its own right will be answered more satisfactorily.

Two major issues regarding ambiguity have been extensively researched; one is the relative difficulty of detecting and/or processing ambiguity at the lexical, surface structure and deep structure levels (e.g. Mackay, 1966; Foss, 1970, Mistler-

Lachman, 1977, Hoppe & Kess, 1980). Many of the studies that tackled this point attempted to relate it to stages of the comprehension process. Despite the intuitive appeal of this trend, it has not yielded any reliable theory of comprehension for two main reasons, namely, the sharp disagreement in research results, and the challenge to surface/deep structures as psychologically valid notions. Most serious of all, in my view, is that the avid interest in this particular research trend has led to the disregard for intersentential effects.

The second issue has to do with psychological models of processing ambiguous sentences. The central question in this regard has been whether all, some, or only one of the possible meanings of a given ambiguous word come to conscious processing, in addition to the role played by context and/or expectation in the resolution of ambiguity. More importantly, in the case of multiple access, is the question how and when is a choice made? This question is particularly relevant to MT and NLP systems.

MODELS OF PROCESSING LEXICAL AMBIGUITY:

Three different models for processing lexical ambiguity can be distinguished: The Prior Search Model (Foss and Jenkins, 1973), Which assumes that prior context somehow determines lexical access. The second model is known as "The Choice-Decision Model"(also labeled the Exhaustive Search Hypothesis by Conrad, 1974, the All Readings Hypothesis by Swinnney and Hakes, 1976, and Hirst, 1987). According to this model, all meanings of the ambiguous word are accessed and checked against the context. In other words, all meanings of the ambiguous word are accessed and processed to determine their compatibility with the context. Thus the effect of context in the interpretive process occurs only after all readings have been accessed. According to Swinney and Hakes 1976, prior context "aids in the selection of an appropriate reading to retain from those accessed, but does not affect the access process itself" (p. 683). The third model is labeled the One Meaning Hypothesis by Foss, (1970), the Garden Path hypothesis by Conrad, (1974), and the Ordered Search hypothesis by Hirst (1987). It assumes that only the dominant reading is accessed and search for other readings is initiated only when the first reading is found to be contextually inappropriate.

LEXICAL AMBIGUITY AND MODELS OF LEXICAL ACCESS:

Lexical access is usually defined as the process of mapping incoming sensory stimuli onto possible candidates in the mental lexicon (see Tanehaus, Dell & Carlson, 1987; Tanehaus & Lucas, 1987). It is also presumed that the process of lexical access involves retrieving all phonological, syntactic, and semantic codes related to a given lexical item. In the case of lexical ambiguity, however, the important question is how the processor identifies the contextually appropriate lexical entry from a number of possible candidates.

One renowned model of lexical access, the Autonomous Model, was proposed by Forster (1979). This model assumes that lexical processing is an independent subcomponent of language comprehension. According to Forster, language comprehension consists of three component processes, lexical, syntactic, and semantic. He postulated three corresponding processors which he labeled lexical, syntactic, and semantic processors. He also assumed that these three processors operate in a linear fashion. Perhaps the most serious (and controversial) claim in Forster's model is the assumption that lexical processing is data driven and unaffected by any information provided by the syntactic and semantic contexts. Thus, non-lexical information cannot influence the processes occurring within the lexicon, and no cognitive penetration can take place in the initial access of lexical entries.

Seidenberg & Tanenhaus (1987) propose a two-stage model of lexical access in which all possible candidates related to the sensory input are activated in the first stage. They refer to this stage as 'prelexical processing', and assume that contextual appropriateness has no effect on the access process at this point. In other words, the first stage is context-independent and insensitive to semantic or pragmatic interpretations provided by the context. The second stage is called 'postlexical processing', and it involves the use of contextual as well as non-linguistic information such as pragmatic sense and world knowledge. The major problem with this model, as it is the case with similar models, is that it does not present any clear-cut demarcation between the two stages, hence, it provides no answer for the long-standing controversy regarding the role of non-lexical information on initial lexical access. Labeling contextual effects as 'post-access' effects does not resolve the issue in view of the fact that some studies reported contextual effects early in lexical processing (see Seidenberg, Waters, Sanders, and Langer, 1984).

In contrast with autonomous models of lexical access, interactive models (see Marslen-Wilson, Brown, and Tyler, 1988; Marslen-Wilson & Tyler, 1980; 1983; 1987) assume that different levels of processing can operate simultaneously and influence one another. Within this framework, contextual information play a major role in the process of lexical access. Various experimental findings were presented in these and in similar studies to counter the modular notions of speed and informational encapsulation and support the context-dependent hypothesis of lexical access.

LEXICAL AMBIGUITY AND MODELS OF LANGUAGE PROCESSING:

Research in the area of natural language comprehension started with fragmentary experiments in free recall, prompted recall, and word association. With the advent of the transformational theory of linguistics the sixties, research attempts focused on correlating ostensible stages of comprehension with the three levels of language proposed by that theory, namely, the deep structure level, the surface structure level, and the lexical realization level. Research in this regard is best exemplified in the works of MacKay 1966; MacKay and Bever, 1967; Foss et al. 1968, and Carey et al. 1970). Also within the framework of the transformational theory, several studies were undertaken to test the effect of different sentence transformations on comprehension time(e.g. Clark, 1965, and Johnson-Laird, 1968).

Attempts to discover the constituents and stages of comprehension are represented in the click-displacement, and phoneme monitoring experiments (Foder and Bever, 1965, Ladefoged, 1967, Reber and Anderson, 1970). The basic assumption of such experiments was that the unit of speech perception corresponds to the constituent. An interesting phenomenon known as 'The Phonemic Restoration Effect' was characterized by Warren (1970). That, in my view, was the first serious attempt at characterizing sentential context effects.

A common factor among all the studies cited above is the disregard for intersentential context effects, or the comprehension of discursive text. It should be noted, however, that some of the studies that tackled sentence ambiguity (e.g. Carey, Mehler and Bever, 1970 (pictorial context); Mistler, 1972) did include some attempts at characterizing context effects. The contexts used, however, were either non-verbal, partial, or unnatural. Moreover, the disambiguating contexts almost always preceded the ambiguous item.

The study of Kintsh (1974) presented a serious attempt at the study of text comprehension. His theory treats the text as a "supersentence", where the mental representations of a given text consists of a concatenation of propositions derived directly from its constituent sentences. This concatenation of propositions is called 'text base'. According to this theory, different surface structures, or texts, with the same meaning, can be produced for any given text (for a full explanation of this theory, see also Sanford and Garrod, 1981). This notion of text base and transformations is analogous to the relation of surface structure and meaning in case grammar. Kintsh's theory was criticized on several grounds including the fact that propositions are hard to define. Most important of all, this theory gives no explicit characterization to what happens during reading. It merely assumes that during reading, propositions are extracted from the text (with additional 'inferential' propositions, if necessary). Perhaps the most serious trouble with the theory is that it cannot handle complex materials, since it was initially tested using rather short passages, sometimes single sentences.

In the seventies, a great deal of interest was also undertaken in the comprehension of stories and how it relates to text grammar (e.g. Lackoff, 1972, Rumelhart, 1975, Thorndyke, 1975; 1976). It should be noted here that work on story comprehension was mostly memory oriented. Also, stories do not represent all types of discursive texts, since their structure is rather formatted and predictable.

The late seventies and early eighties witnessed a major thrust of studies that tackled the semantic and pragmatic effects of grammar (see Dick,1978; Forster, 1979; Givon, 1980; Kuno, 1980). Such studies yielded a number of functionalist models of sentence processing based on 'performance grammar'. One famous model, the Competition Model, has prompted a remarkable surge in experimental research, which continues up to the present time. It is a probabilistic model of language comprehension based on a functional theory of grammar in which the relationship between the underlying meanings and intentions, and their surface representations is stated in a direct fashion (for a discussion of the linguistic and psychological assumptions underlying this model, see Bates & MacWhinney, 1981, 1982, 1987; MacWhinney, Bates& Kliegl, 1984; MacWhinney, 1990; Taman, 1993)

One of the long standing controversies in psycholinguistic research, however, is whether language processing is highly interactive or highly specialized, and whether lexical access is an autonomous or integrated process. According to the functionalist viewpoint (see, for instance, Fillenbaum, 1974) language system is considered too impoverished to function independently. It is also argued that the stimuli we receive during language processes are relatively imperfect and inadequate, and therefore unreliable. This makes it mandatory for a language processing system to allow other sources of nonlinguistic knowledge, such as contextual and pragmatic information, to intervene.

In contrast to the functionalist assumption, some researchers (e.g. Chomsky, 1980) argue that language processes can be regarded as a specialized multilevel system which is different and independent from the general cognitive system.

Perhaps the most influential work contradicting the functionalist view is Fodor's Modularity Hypothesis (Fodor, 1983, 1985, 1987). According to this hypothesis, stimulus information passes through three distinct processing systems, namely, transducers, input analyzers, and the central system. He further assumed that input analyzers are 'informationally encapsulated' by virtue of being reflexive, and that the language comprehension mechanism is functionally similar to the perceptual mechanism. The most important implication of this view is that modular processes are completely data-driven, since they resist the cognitive penetration from higher centers. Thus, modular processes take place during lexical access, and central (or Knowledge driven) processes can intervene only later.

It should be noted here that, contradictory to this view, the interactive models of language processing allow for non-modular processes to occur very early during access of lexical items. Thus, the underlying mechanism for language processing is a general cognitive system in which various kinds of knowledge can communicate and interact with one another. Various experimental results that are often cited in support of the Modularity Hypothesis can be interpreted to support the interactive role of contextual information. A good example of this is Dell's (1991) reinterpretation of the data in Levelt et al. (1991); the data were taken to agree with the predictions of a two stage theory of lexical processing, but Dell et al. (1991) discuss how the same data can be reconciled with interactive spreading-activation theories of language production. Recent experimental results (e.g. Berg, 1992; Walczyk et al. 1992; Levelt et al. 1991) can also be interpreted along these lines.

RESEARCH PROBLEM AND STATEMENT OF PURPOSE:

The issue of lexical ambiguity resolution is closely related to the notion of lexical access, which is in turn related to the phenomenon of language processing. Any attempt to characterize lexical ambiguity whether for theoretical or for practical purposes (e.g. automatic processing of natural language) should take into consideration the dynamic relationship among these three phenomena. In other words, a model of lexical disambiguation that does not take into consideration the process of lexical access, and the nature of language processing in general is likely to be extremely inadequate. Conversely, models of language processing should comprise an adequate characterization of lexical access, which, in turn, can be best studied in the framework of lexical ambiguity.

One remarkable observation about the studies discussed above is the absence of integration between the various levels of language analysis. Despite the intuitive relationship between lexical access and language processing, both phenomena have been tackled more or less independently. This is reflected very clearly in the inadequate characterization of higher level information in lexical access. The bulk of studies on lexical access, as shown above, were concerned with lexical decision tasks or phoneme monitoring.

Also, studies that attacked the issue of lexical ambiguity resolution were limited to sentential context. It goes without saying that immediate context clues, such as semantic and syntactic co-occurence restrictions help resolve ambiguities within a sentence. However, in the majority of cases, the sentential context is not sufficient, and ambiguities are resolved only by extrapolating beyond sentential context. It is true that, compared to lower level information, higher level information cannot be easily subjected to quantitative analysis, and that explains the dearth of experimental research in that respect. Another plague, in my view, is that experimental findings, which are highly contradictory to begin with, are almost always cited in support of one theoretical model or another instead of being utilized in the formulation of a functional model that stems from serious, target-oriented experimentation.

The inadequacy of existing models shows very clearly in any attempt to apply them in NLP systems (see Hirst, 1987). In essence, psycholinguistic theory, to date, has failed to present an adequate functional model of language processing that integrates such aspects as lexical access and lexical and other types of ambiguity in a dynamic relational format. There is a pressing need for a feasible characterization of such phenomena in the design and implementation of AI and MT systems, particularly in the design of lexical data bases to interface with such systems.

One important issue that should be addressed in this endeavor is the integration and utilization of information obtained from previous context (text knowledge), in addition to the listener/reader's experience (world knowledge). After all, text is but a concatenation of sentences that contribute, collectively and addatively, to the transmission of a communicative intent. A model that considers single sentences out of their context would fail to capture textual and contextual effects on the process of comprehension. Similarly, a model that regards the reader/listener background knowledge as zilch, would certainly fail to capture information highly relevant to the process of language understanding. It is through such clues that an active process of inferencing is triggered, an activity indispensable to successful discourse processing and text representation. For a discussion of the important role of inferencing in language processing see Garnham & Oakhill; 1992, Roller et al., 1992; Mondria et al., 1991; Hammadou, 1991.

A good model of language processing should then incorporate an adequate characterization of text and world knowledge (TWK), particularly *how* and *when* such knowledge is invoked and what effect does it have in handling processing difficulties such as structural complexity and lexical ambiguity. In fact, this issue has been addressed in the psycholinguistic literature, albeit unsatisfactorily. In the late seventies and early eighties, two main theories were presented in an attempt to characterize knowledge access, namely, a text-based propositional theory, best represented in the work of Clark (1975), and Clark and Haviland (1977), and a scenario-based theory, best represented in the works of Schank and Abelson (1977), and Charniak (1984). This last theory was developed and tested in a computational framework as in the case of the well-known SAM program (Cullingford, 1978; Schank and the Yale AI Project, 1975).

According to the text-based theory, knowledge plays a limited role in the construction of mental representations. The major problem that the reader encounters is linking together text-based propositions, so the essential mechanism lies in using propositional argument repetition as a means of cohesion. If, and only if, argument repetition fails, is background knowledge invoked. That theory was tested mainly on reference, and it was criticized for overemphasizing the role of syntax. It was found that, although syntactic signals in a given sentence force the reader to look for antecedent to given information, the reader often seems to infer connections in the absence of appropriate given-new clues. It was also demonstrated that syntax is not sufficient to block context-driven checks for semantic relationships between what is currently being interpreted and what has just been read.

In the Scenario Theory, on the other hand, knowledge plays a major role in the comprehension process. According to this theory, the reader has two different tasks to perform, namely, identifying an appropriate domain of reference (or scenario) that corresponds to what is the text is about, and using the identified domain of reference to interpret the subsequent text. So, whereas the sequence of action in the text-based theory is [text---propositional episodes---(knowledge)---interpretation), the sequence in the scenario theory is [text---knowledge---episodes-interpretation]. In spite of the fact that this last theory was tested in a computational framework, it has been criticized on various grounds, not least of which is the questioning of its psychological reality. In addition, it was not completely successful at the computational level (see Arbib et al., 1987). It should be mentioned here that some recent studies (c.f. Walczyk, 1992; Beauvillain, 1994; Andruski, 1994) minimize the role of scripts in the process of lexical access, but, again, the experimental task in such experiments, being word reading or word naming, does not coincide with the nature of script processing. Such findings are often cited in support of the modularity theory.

Since the resolution of lexical ambiguity necessarily involves both textual and as well as contextual knowledge, it can be best explained in a model that is both text-based and knowledge-based. In other words, we need to characterize the relationship between word sense and conceptual mechanisms (e.g. schema, scripts, scenarios, plans) invoked by the processor's inherent capacities as well as its dynamic organization and re-organization of input information. Lexical ambiguity is not necessarily resolved by information present in the same sentence in which the ambiguous word occurs, as assumed in the majority of experiments. Also, ambiguity is not necessarily resolved by subsequent context exclusively, as it has often been assumed. In addition, disambiguating information is not necessarily present in the immediate sentential context, but it might be traceable in the distant preceding or subsequent context. Above all, bias towards one sense or another of the ambiguous word can play a significant role in the process of disambiguation; schizophrenia patients often interpret ambiguous words only with their most frequent meaning, even if the result is nonsense, which indicates that the most frequent sense is psychologically distinguished (see Hirst, 1987).

Thus, there are four different possibilities of text-context resolution of lexical ambiguity, these are:

1- Immediate proactive disambiguation, in which the disambiguating context immediately precedes the ambiguous word.
2- Distant proactive disambiguation, in which the disambiguating context precedes the ambiguous word, distanced by intervening text.
3- Immediate retroactive disambiguation, in which the in which the disambiguating context immediately follows the ambiguous word.
4- Distant retroactive disambiguation, in which the disambiguation context follows the ambiguous word, distanced by intervening text.

To my knowledge, the above possibilities and their permutations have never been considered all together (see Seidenberg et al.

1982; Ryder and Walker, 1982; Oden and Spira, 1983; Hirst, 1987). If we take bias into consideration, another set of four possibilities will emerge. Thus, the present study will consider eight different contextual disambiguation mechanisms (see figure 1), with the aim of characterizing the role of contextual information, and the way such information is accessed and utilized in on-line comprehension.

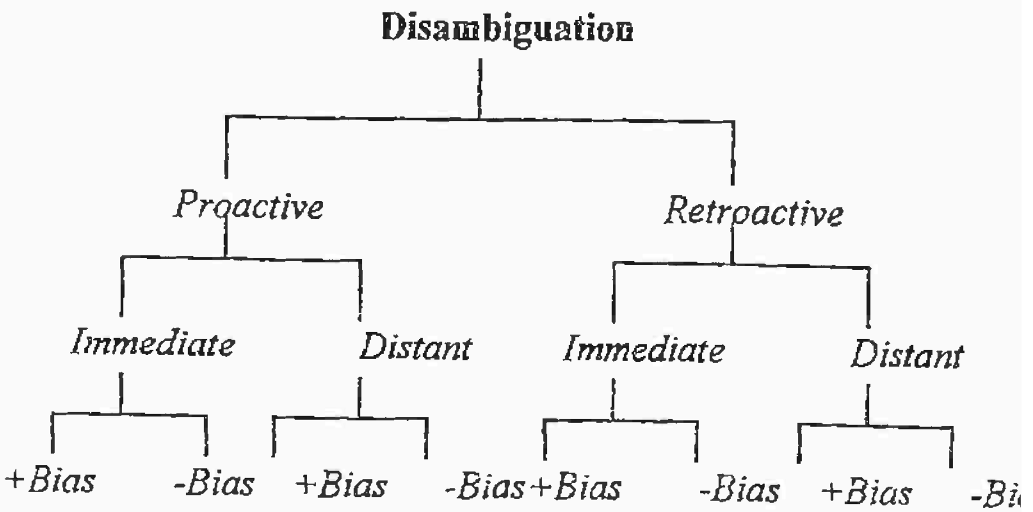


Figure 1-A :A Diagram Representing The Eight Disambiguation Mechanisms.

(*) *ambiguous word*
⊙ *biased disambiguating context*
□ *non-biased disambiguating context*
..... *intervening text*

1 (*) .... ⊙
2 (*) ⊙
3 ⊙ .... (*)
4 ⊙ (*)

5 (*) .... □
6 (*) □
7 □ .... (*)
8 □ (*)

Figure 1-B :A Schematic Representation of the Contextual Disambiguation Mechanisms

STUDY QUESTIONS:

The study seeks to answer the main question of when and how higher level (non-textual) information penetrates the process of comprehension; is it accessed spontaneously, or only when the process of comprehension stalls (i.e. when textual input is insufficient or ambiguous)? Is it always present at conscious level or is it accessed in a self-optimizing fashion? This question gives rise to the following questions:

1- When an ambiguous word is encountered and the previous context does not provide any clue as to the contextually appropriate interpretation, does the processor access a single reading or multiple readings?

2- If multiple readings are accessed, does the distance between the disambiguating context and the ambiguous word affect the maintenance of those readings?
3- If a single reading is accessed, is it a function of bias or dominant sense?
4- If a single reading is accessed as a function of bias, what effect does subsequent context have in the maintenance of this reading?
5- If subsequent context is incongruent with a biased reading, does this invoke a process of backtracking?

WORKING HYPOTHESIS:

The present study presumes that higher level (non-textual) knowledge plays a major role in the process of comprehension in general, and the process of lexical disambiguation in particular. It also presumes that higher level information penetrates the process of comprehension all through, and is normally invoked with the minimal textual input. When an ambiguous word is encountered, and the previous context does not provide any clue as to the contextually appropriate reading, an interpretation is adopted as a function of bias or frequency. Two possibilities might take place in this case, i.e. subsequent context may be congruent or incongruent with the selected reading. If subsequent context is incongruent with the selected reading, a process of backtracking will be initiated. The longer the distance between the ambiguous word and the disambiguating context in this last case, the longer the reading time.

It should be noted that, if both readings are maintained until a disambiguating context is encountered, or if no macrotextual or contextual information has been accessed, there would be no difference between reading time in cases where the disambiguating context confirms a biased reading or a non-biased one. Moreover, reading time for texts in which the disambiguating context precedes or follows the ambiguous word should be more or less the same.

METHOD:

Materials:

A list of 40 ambiguous Arabic words was presented to 200 university students, all native speakers of Arabic. They were asked to use each word in a sentence. The list was presented to them in writing, and their responses were tape recorded. The respondents were instructed to consider the words in the list, one by one, and to use each one in a sentence that best expresses its meaning. Responses were then tabulated according to the senses of each ambiguous word, and the number of respondents who favored one sense or the other. 10 words that exhibited response polarity, i.e. high degree of bias towards one meaning as opposed to the other(s) (>90%), were chosen for the experiment. Respondents who participated in the test for bias did not take part in the actual experiment.

200 Arabic text fragments were then constructed, twenty for each ambiguous word in accordance with the experimental conditions outlined in figure 1. The text fragments constructed for each ambiguous word comprised a sentence in which the ambiguous word was embedded, a sentence containing a disambiguating context, and, depending on the experimental condition (see figure1), a third sentence separating the

ambiguous fragment from the disambiguating context. This last sentence was always neutral as far as ambiguity resolution was concerned. Its sole function was to distance the ambiguous text from the disambiguating context.

Depending on the sequence of the ambiguous fragment and the disambiguation context, the presence or absence of distancing fragment, and the bias condition, each ambiguous word appeared in eight experimental conditions comprising two or three fragments that, together, form a coherent episode (to be used interchangeably with 'text structure'). Sentences in the parallel experimental conditions were constructed in such a way that they had the same number of words, the same number of morphemes and the same number of transformations, to control for ease or difficulty of comprehension.

The fragment with the ambiguous word, together with the distancing fragment were constructed in such a way that allows more than 250 Milliseconds of Stimulus Onset Asynchrony (SOA) between the ambiguous word and the disambiguating context. This was meant to allow for lexical access and lexical processing (according to the Autonomous Models) to take place (for a discussion of the concept of SOA, see Tanenhaus & Lucas, 1987).

For convenience of illustration an example will be given here in English (see appendix 1 for an example in Arabic): consider the English word 'fan', which has two different meanings, namely, the sense of an air propeller, and the sense of a sports fan, for instance. Assuming that the reader is biased towards the first meaning, the eight experimental conditions for the word 'fan' can be illustrated as follows (refer to figure 1):

1- "Never mind the fans,"/ He said after thinking for a while/ "We can always turn on the air conditioning unit". ***(biased, distanced, retroactive disambiguation*).**

2- "Never mind the fans," / "We can always turn on the air conditioning unit". ***(biased, retroactive, non-distanced disambiguation).***

3- "We can always turn on the air conditioning unit"/ He said after thinking for a while/ "So, never mind the fans" ***(biased, distanced, proactive disambiguation).***

4- "We can always turn on the air conditioning unit" / "So, never mind the fans". ***(biased, non-distanced, proactive disambiguation*).**

5- "Never mind the fans,"/ He said after thinking for a while/ "We can always put off the mud wrestling contest". ***(non-biased, distanced, retroactive disambiguation*).**

6- "Never mind the fans," / "We can always put off the mud wrestling contest". ***(non-biased, non-distanced, retroactive disambiguation)***

7- "We can always put off the mud wrestling contest" / He said after thinking for a while / "so never mind the fans," / . ***(non-biased, distanced, proactive disambiguation)***

8- "We can always put off the mud wrestling contest" / " So, never mind the fans." ***(non-biased, non-distanced, retroactive disambiguation)***

TABLE 1

The Rotation of the Experimental Conditions in the Eight Experimental Groups.

SEN	GROUP							
	1	2	3	4	5	6	7	8
1	1	2	3	4	5	6	7	8
2	2	3	4	5	6	7	8	1
3	3	4	5	6	7	8	1	2
4	4	5	6	7	8	1	2	3
5	5	6	7	8	1	2	3	4
6	6	7	8	1	2	3	4	5
7	7	8	1	2	3	4	5	6
8	5	6	6	8	1	2	3	4
9	5	6	7	8	1	2	3	4
10	1	2	3	4	5	6	7	8

Table 2

The Representation of Experimental Conditions in the Eight Stimulus Groups.

Condition	Stimulus group/Episode									
1	1/1	8/2	7/3	6/4	5/5	4/6	3/7	1/8	1/9	1/1[illegible]
2	2/1	1/2	8/3	7/4	6/5	5/6	4/7	2/8	2/9	2/1[illegible]
3	3/1	2/2	1/3	8/4	7/5	6/6	5/7	3/8	3/9	3/1[illegible]
4	4/1	3/2	2/3	1/4	8/5	7/6	6/7	4/8	4/9	4/1[illegible]
5	5/1	4/2	3/3	2/4	1/5	8/6	7/7	5/8	5/9	5/1[illegible]
6	6/1	5/2	4/3	3/4	2/5	1/6	8/7	6/8	6/9	6/1[illegible]
7	7/1	6/2	5/3	4/4	3/5	2/6	1/7	7/8	7/9	7/1[illegible]
8	8/1	7/2	6/3	5/4	4/5	3/6	2/7	8/8	8/9	8/1[illegible]

(Notice the equivalence of 'we can turn on the air conditioning unit', and 'we can put off the mud wrestling contest').

A similar set of stimuli was constructed for each of the ten Arabic ambiguous words. The 80 stimulus episodes of the ten words were then put in eight different groups in such a way that each of the eight experimental conditions appeared only once for each word within each group. The episode types were rotated so that the eight groups were equivalent in the number and types of experimental conditions. This was meant to control for any possible primacy effects or intergroup variance. Table 1 shows the rotation of the experimental conditions in the eight experimental groups. For instance, group four comprised episode 1 in experimental condition 4, episode 2 in experimental condition 5, and so forth. Table 2 shows the representation of experimental conditions in the eight gronps. For instance, experimental condition 1 (distant retroactive disambiguation-see figure 1) can be found in episode one of group one, episode two of group eight, episode three of group seven and so forth. This table will be used as basis for statistical comparisons among the various experimental conditions.

Procedure:

The aim of this experiment was to measure the reading time for the various experimental episodes. A program was written in BASIC to present the data and measure the reading time in milliseconds. The episode fragments were flashed on the computer screen one after the other in a 'reader controlled text window' (self-paced reading task). A beep sound marked the end of an episode. The program consisted of eight modules, one module for each experimental group.

respondents were not told that their reading was being timed. A practice demo was given at the beginning of every session. The demo did not include any of the actual stimulus materials. Respondents were allowed to re-run the demo until the experimental task was fully understood.

Pilot study:

A pilot study was conducted with the aim of testing the experimental apparatus, preparing a set of instructions, and exploring any difficulties that might arise during the actual experiment. Ten respondents took part in the pilot study. The results of the pilot study showed that respondents might tend to interrupt their reading before the beep in order to ask the experimenter for clarification. It was also found that some respondents might regard episode fragments as unrelated or nonsensical. The most serious problem was mishitting, that is, pressing the ENTER key longer than necessary resulting in multiple presentations of fragments. All these remarks were taken into consideration when preparing the instructions and the apparatus for the actual experiment.

RESULTS:

The data in the eight experimental groups were rearranged and tabulated according to the eight experimental episode types (see figure 1). For instance, reading time for all instances of immediate proactive non-biased disambiguation (type 1) were grouped form episode 1 of group 1, episode 2 of group 8, episode 3 of group 7, and so forth (see table 2). Table 3 shows mean reading time in milliseconds for the eight experimental text structures, and figure 2 is a graphic representation of the data in this table.

Sample:

The target sample size was 80ss, but 237 undergraduate students at the Faculty of Education Alexandria University participated in this experiment. Due to the circumstantial nature of the experimental task, the responses of 157 students were excluded, either because they failed to follow the instructions of the experiment, or failed to comprehend the experimental episodes, or because of mechanical problems in recording their responses. In every case, alternative respondents were recruited to participate in the experiment until the target sample size was reached. All respondents were native speakers of Arabic with normal (or corrected) vision, and all were graduates of governmental secondary schools. Each respondent was randomly assigned to one of eight experimental groups.

Apparatus and experimental task:

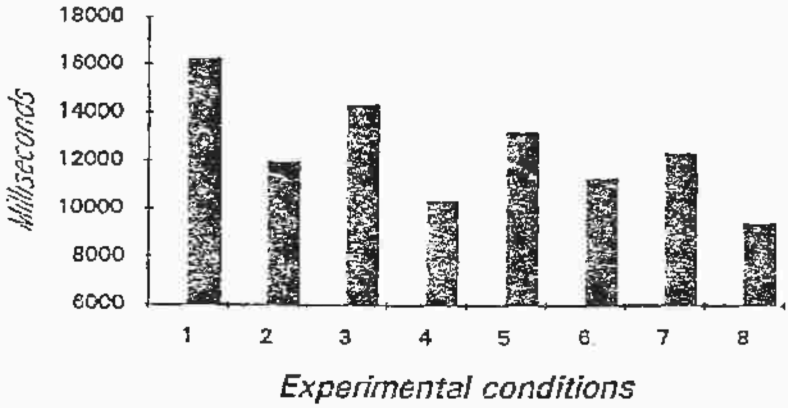
The stimulus materials were presented in an IBM compatible microcomputer. Response times were measured and recorded using a program written in BASIC. Latency measurements were accurate to within one millisecond.

Respondents were tested individually. Each respondent was seated 50 cm from the computer screen. He/she was asked to rest the index finger of his/her dominant hand on the ENTER key of the keyboard. Respondents were told that they would be presented with a written episode that would appear on the screen in two or three installments. They were further told that they could control the appearance of the episode fragments by hitting the ENTER key. They were supposed to hit the ENTER key after comprehending the fragment. A beep sound indicated the end of the episode, thereon, they were supposed to stop and paraphrase the whole episode to the experimenter. The

Table 3:Mean Reading Time in Milliseconds for the Eight Experimental Text Structures.

Condition	N	Mean	Std.dev.	Minimum	Maximum
1	100	16248.0400	869.2564	12601	17869
2	100	11958.2500	934.3916	10029	13968
3	100	14313.7800	872.9461	12128	16003
4	100	10337.1800	900.4756	8890	11989
5	100	13210.8600	939.6645	10129	14977
6	100	11285.9700	893.7741	9897	13620
7	100	12308.1100	837.1290	10837	13989
8	100	9381.8100	900.1362	7889	12049

Figure 2: Reading time in the eight experimental conditions



According to table 3, the eight experimental conditions rank order as follows in terms of reading time;

1- Distant non-biased retroactive disambiguation.
2- Distant non-biased proactive disambiguation.
3- Distant biased retroactive disambiguation.
4- Distant biased proactive disambiguation.
5- Immediate non-biased retroactive disambiguation .
6- Immediate biased retroactive disambiguation.
7- Immediate non-biased proactive disambiguation.
8- Immediate biased proactive disambiguation.

This rank order shows that immediate disambiguation takes less time than distant disambiguation. This is only intuitive by virtue of the latency created by the distancing text. What we need to know, however, is the effects of bias (biased vs. non-biased), the direction of disambiguation (proactive or retroactive), and finally, bias and direction combined. To achieve this, a cross comparison between corresponding pairs of experimental conditions was conducted in the following fashion:

Bias: 1x5; 2x6; 3x7; 4x8
Direction: 1x3; 2x4; 5x7; 6x8
Bias & Direction: 1x7; 2x8; 3x5; 4x6

Table 4 presents a comparison of means, standard deviations, and T-test results of corresponding text structure types representing the effect of bias. As shown in this table, reading time was significantly higher in condition one as compared to condition five, in condition two as compared to condition six, in condition three as compared to condition seven, and in condition four as compared to condition eight. T-test results show that the differences between pairs of conditions were statistically significant at $p<0.01$, except in the case of condition two vs. condition six. It should be taken into consideration here that conditions 1,2,3 &4 represent the non-biased condition, that is text structures in which the disambiguating context supports the unbiased sense of the ambiguous word, whereas conditions 5,6,7 & 8 represent the biased condition, that is text structures in which the disambiguating context supports the biased sense of the ambiguous word. This means that bias plays an important role in the access and utilization of both textual and non-textual information.

Table 4
T-Test Results of Text Structure Types Representing the Effect of Bias.

Variable	Mean	Std. Dev.	d.f.	T value	P
1 5	16248.0400 13210.8600	869.2564 939.6645	99	41.43	*
2 6	11958.2500 11285.9700	934.3916 893.7741	99	5.96	
3 7	14313.7800 12308.1100	872.9461 837.1290	99	36.14	*
4 8	10337.1800 9381.8100	900.4756 900.1362	99	16.29	*

(*) Singificant at P<0.01

Table 5 presents a comparison of means, standard deviations, and T-test results of corresponding text structure types representing the effect of direction of disambiguation or the sequence of text fragments. It should be noted that types 1,2,5 & 6 represent retroactive disambiguation, and they correspond respectively to types 3,4,7 &8, which represent proactive disambiguation. Types, 1,3,5 &7 represent distant disambiguation, whereas types 2,4,6 &8 represent immediate disambiguation. As shown in table 5, reading time is significantly higher for retroactive disambiguation. T-test results show that the differences between corresponding conditions were significant at $P<0.01$, except conditions 2 vs.4 and 5 vs. 7.

Table 5
T-Test Results of Sentence Types Representing the Effect of Fragments Sequence.

Variable	Mean	Std. Dev.	D.F.	T Value	P
1 3	16248.0400 14313.7800	869.2564 872.9461	99	32.02	*
2 4	11958.2500 10337.1800	934.3916 900.4756	99	14.63	
5 7	13210.8600 12308.1100	939.6645 837.1290	99	14.59	
6 8	11285.9700 9381.8100	893.7741 900.1362	99	26.14	*

(*) Singificant at $P< 0.01$.

Table 6 presents a comparison of means, standard deviations, and T-test results of corresponding text structure types representing the effect of sequence and bias combined. This comparison involves text types 1,2,3 &4 respective to text types 7,8,5,&6. Results show that text structures with non-biased disambiguating context exhibit longer reading time regardless of the sequence of text fragments. T-test results show that the differences between corresponding conditions were significant at $P<0.01$, except condition 4 vs. condition 6.

Table 6

T-Test Results of Sentence Types Representing the Effect of Sequence and Bias Combined.

Variable	Mean	Std.Dev	D.F	T Value	P
1 7	16248.0400 12308.1100	869.2564 837.1290	99	68.93	*
2 8	11958.2500 9381.8100	934.3916 900.1362	99	22.05	*
3 5	14313.7800 13210.8600	872.9461 939.6645	99	18.62	*
4 6	10337.1800 11285.9700	900.4756 893.7741	99	13.40	

(*) Singificant at P <0.01.

Reading time for individual text fragments was also considered. Specifically, the reading time for fragments representing the ambiguous stretch, the distancing text, and the disambiguating text across the various textual conditions was tabulated separately. As far as the ambiguous stretch is concerned, there were five different conditions that can be shown along with their mean reading times in table 7. Figure 3 is a graphic representation of the data in this table. Notice that the reading time of the ambiguous fragment is higher when it follows a non-biased disambiguating context, more so when it follows both the disambiguating context and the distancing text. The latency measures for the ambiguous fragments in initial position, and following biased disambiguating contexts are not significantly different.

Table 7
Mean Reading Time for Ambiguous Fragments in the Various Textual Conditions.

Fragment Position	Text Type	Mean R.T.
Initial	1,2,5,6	4184.47 Msc.
Final, non-distant, non-biased	4	5042.75 Msc.
Final, non-distant, biased	8	4223.92 Msc.
Final, distant, non-biased	3	5766.78 Msc.
Final, distant, biased	7	4328.02 Msc.

noted that disambiguating fragments are congruent with either the biased or the non-biased interpretation of the ambiguous fragment. In either case, the disambiguating fragment could occur in initial position, in final position following the ambiguous fragment only, or in final position following both the distancing text and the ambiguous fragment. This creates six different contextual possibilities for the disambiguating fragment. However, since bias is neutralized in initial position by virtue of the fact that the ambiguous fragment is not yet encountered at that point, only five contextual possibilities of disambiguating fragments were considered. In other words, the mean reading time of disambiguating fragment in initial position is the average mean of text types 3,4,7&8. Table 8 shows the mean reading time for disambiguating fragments in the various textual conditions. Figure 4 is a graphic representation of the data in table 8.

Figure 4: A graphic representation of the data in table 8

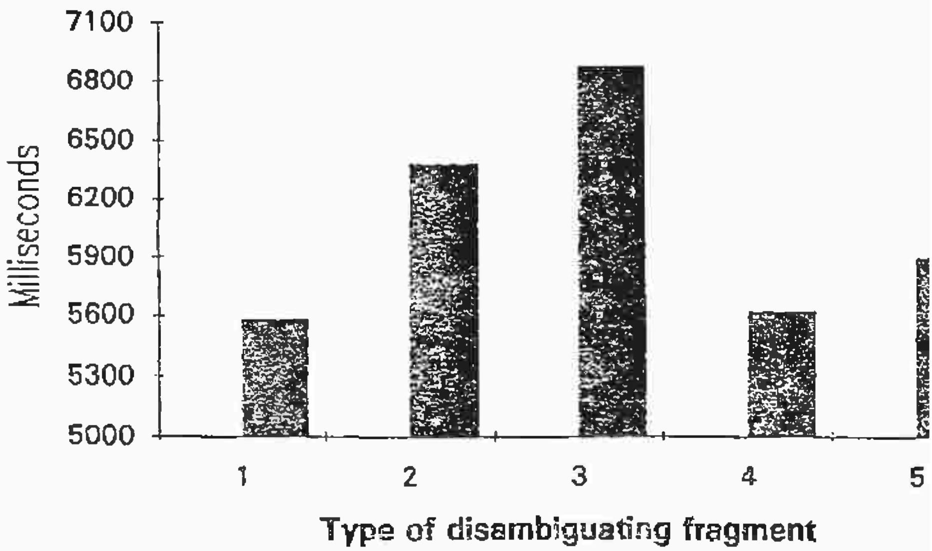
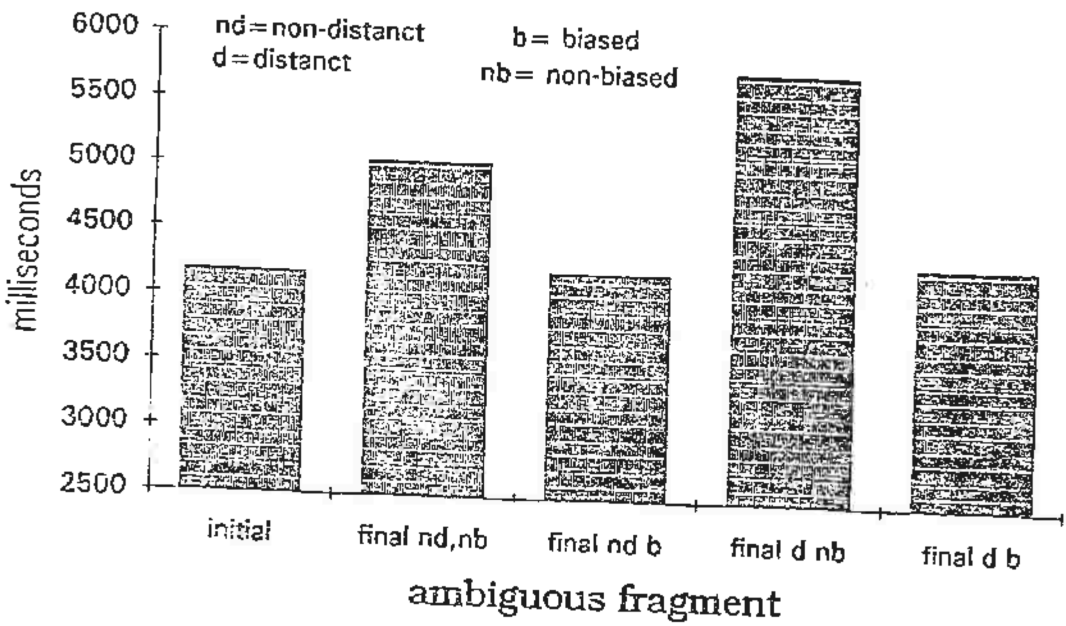


Fig. 3: Reading time for the ambiguous fragment in the various contextual conditions



No significant differences were found in the reading time of the distancing text in the three different contexts, namely, following the ambiguous fragment, following the non-biased disambiguating fragment, and following the biased disambiguating fragment. The first context is represented in text types 1&5 (mean R.T.= 5212.1 Msc.), The second context is represented in text type 3 (mean R.T. = 5415.1 Msc.), and the third context is represented in text type 3 (mean R.T. = 5553.1 Msc.).

The reading time of disambiguating fragments in the various contexts is particularly important as far as the basic assumptions of the present study are concerned. It should be shows that latency in reading for comprehension is higher in distant vs. immediate disambiguation, for non-biased vs. biased cases, and for retroactive vs. proactive disambiguation. These results tend to emphasize the role of bias in activating higher level knowledge structures that guide the process of comprehension. One plausible explanation for the higher latencies in the case of retroactive disambiguation is that it involves a process of backtracking, particularly when the disambiguating context confirms the non-biased reading. It also indicates that non-textual information is accessed early in the process of comprehension. This conclusion contradicts the principles of the Modularity Hypothesis.

This observation is also confirmed in the analysis of the effect of bias, direction, and bias and direction combined in the corresponding text structures. In the case of bias, episodes 1,2,3 & 4 were compared respectively with episodes 5,6,7 & 8. In episodes 1,2,5 & 6 , and in the absence of previous context, a scenario is invoked as a function of the biased reading of the ambiguous word. In the case of episodes 1 & 2, the invoked scenario is incompatible with the disambiguating context, and a process of backtracking is consequently initiated. In the case of episodes 5 & 6, on the other hand, the provoked scenario is validated, and no backtracking is involved. This explains the higher latency measures for episodes 1 and 2 as compared to episodes 5 and 6. Intervening text between the ambiguous word and the disambiguating context seems to consolidate the invoked scenario. For this reason, the difference between episode 1 and episode 5 is greater than the difference between episode 2 and episode 6. Moreover, the difference between means in this last case is not significant at $p<0.01$ (see table 4).

In the case of episodes 3, 4, 7 & 8, a disambiguating context is provided before the ambiguous word is encountered.

Table 8
Mean Reading Time for Diambiguating Fragments in the Various Textual Conditions.

Condition	Fragment position	Bias	Text Type	Mean R.T.
1	Initial	--------	3,4,7,8	5583.[illegible]
2	following ambiguous fragment only	non-biased	2	6382.[illegible]
3	following ambiguous fragment +distance	non-biased	1	6884.[illegible]
4	following ambiguous fragment only	biased	6	5625.
5	following ambiguous fragment + distance	biased	5	5903.

INTERPRETATION OF RESULTS:

It is presumed that relative differences in reading-for-comprehension time reflect corresponding differences in the amount of cognitive processing in a given unit of language data. On the basis of this assumption, reading-for-comprehension time was analyzed for the eight text structure types involving lexical ambiguity (see figure 1), in addition to the various fragments within those types. Preliminary analysis (see table 3)

Again, a scenario is invoked on the basis of this context. In episodes 3 and 4, however, an ambiguous word is encountered. Since the biased reading of the ambiguous word is incongruent with the invoked scenario, this dominant reading is deactivated, and a search for the congruent reading is initiated. It is also possible that a process of backtracking is initiated in an attempt to reconcile the meaning of the ambiguous word with the invoked scenario. As a result, the mean reading time is significantly higher in episodes 3 and 4 than in episodes 7 and 8 in which the biased meaning of the ambiguous word is congruent with the invoked scenario.

To test the effect of direction, episodes 1,2,5 &6 were compared respectively to episodes 3,4,7 & 8. On the whole, the results of the present experiment show higher latencies for retroactive than for proactive disambiguation. However, only differences in the case of distant retroactive disambiguation are statistically significant ($p<0.01$). One plausible explanation for this is that when a scenario is invoked as a function of the biased reading of the ambiguous word as in episodes 1,2,5 &6, it remains tentative until validated or invalidated by subsequent text, but when the disambiguating text is encountered first, as in episodes 3,4,7 &8, the transition between presumed and confirmed information is relatively smoother. In other words, there is no conflict between higher level and lower level information, particularly when the subsequent ambiguities are congruent with preceding information. However, when a conflict exists between higher and lower level information, that is, when the relationship between the biased meaning of the ambiguous word and the disambiguating context is incongruent, the difference between proactive and retroactive disambiguation is no longer significant. This explains the statistically significant differences between episodes 1 and 3, but not 5 and 7. Notice also that provoked scenarios persist when reinforced by distancing text. This explains the smaller differences between proactive and retroactive disambiguation in the absence of distancing text. The effect of distancing text is also affected by bias; the difference between episode 5 and episode 7 is statistically significant, whereas the difference between episode 2 and episode 4 is not.

The results of the effect of sequence and bias combined (see table 6) also show that higher level information is accessed early in the process of comprehension, and that incongruity between textual and non-textual information results in reading latency since it involves a process of backtracking of some kind. The results of analyzing reading time latencies for the ambiguous fragment in the various contexts support the above conclusion: the incongruity between the scenario invoked by non-biased disambiguating context and the biased reading of the ambiguous fragment results in higher latencies. Reading latencies are even higher in this case when the ambiguous fragment is preceded by both the non-biased disambiguating context and the distancing text, since, as mentioned earlier, the distancing text reinforces the invoked scenario. Because no incongruity is involved when the ambiguous fragment follows a biased disambiguating context, reading time in this case is not significantly different from that of the ambiguous fragment in initial position.

Results indicate that the reading time of the distancing text is not affected by the type of the preceding context, presumably because it is always compatible with any scenario that could be invoked by either the ambiguous fragment, the biased disambiguating context, or the non-biased disambiguating context. However, distancing text has the effect of consolidating the invoked scenario and thus increasing latency in backtracking as mentioned earlier.

The analysis of reading-for-comprehension (RFC) latencies in the disambiguating fragment offers significant results. It should be noted again that the disambiguating fragment could be either congruent or incongruent with the biased reading of the ambiguous word, and that it could occur in initial position, in final position following the ambiguous fragment only, or in final position following both the ambiguous fragment and the distancing text. Results indicate that higher level information penetrate the process of comprehension from the beginning, and that bias plays a major role in deciding the nature of non-textual information. As shown in Table 8, higher latencies occurred in non-biased vs. biased contexts, and in distant vs. immediate contexts. Disambiguating fragments exhibited the lowest latency in initial position, and the highest latency in distant, non-biased contexts. Again, it can be assumed that non-biased disambiguating fragments take longer to process because they are incongruent with an already invoked scenario, and that distancing text reinforces that scenario. The varying latencies can be explained in terms of the reader's attempt to reconcile the maintained scenario with the conflicting information presented in the disambiguating fragment. The rank order of RFC latencies in table 8 supports this assumption.

CONCLUSION:

The results of the present study indicate that resolving lexical ambiguity occurs within the framework of a scenario element based on text input, text knowledge, and higher level knowledge. Incongruity between textual information and other textual or higher level information has adverse effects on latencies in the processing of language data.

The process of lexical access can also be viewed from this perspective; throughout the process of comprehension, the processor has continuos access to higher level (non-textual) information. Scenarios are created, modified, or changed as a result of a dynamic process of resolving incongruities between textual/textual, textual/non-textual, or non-textual/non-textual information. Lexical access cannot be viewed independently from higher level information. Rather, it should be viewed as integral element in the dynamic chain of invoking scenarios, integrating data fragments, and resolving conflict in the flow of information in a horizontal (textual) or vertical (contextual) fashion. In this way, lexical access could, depending on the state of the processor, trigger, or be triggered by higher level information. Also, depending on the quantitative/qualitative relationship between higher level and lower level information at a given point in the process of comprehension, the process of lexical access may involve an exhaustive, random, or guided search for lexical candidates. This might explain the contradicting claims and experimental findings of the various models of lexical access. However, it should be noted that the present results offer more support to Interactive Models than to Autonomous Models of lexical access.

The invocation of initial scenarios and checking them against subsequent text indicates that higher level knowledge is accessed extemporaneously, and refers to both text knowledge and world knowledge. The processor has continuos access to this type of knowledge. A scenario is invoked with a minimal textual input, and other forms of higher level knowledge as well as subsequent textual information are utilized on the basis of the invoked scenario. With the progress of text, and depending of the state of the processor, subsequent textual information has three basic functions, namely, invoking new congruent scenarios, validating and reinforcing active scenarios, and voiding active scenarios and activating alternatives. It is to be noted also that the process of knowledge access is different from the process of knowledge utilization; whereas knowledge access functions to invoke initial scenarios, knowledge utilization functions to integrate textual input with contextual and pragmatic information, and to concoct forthcoming input.

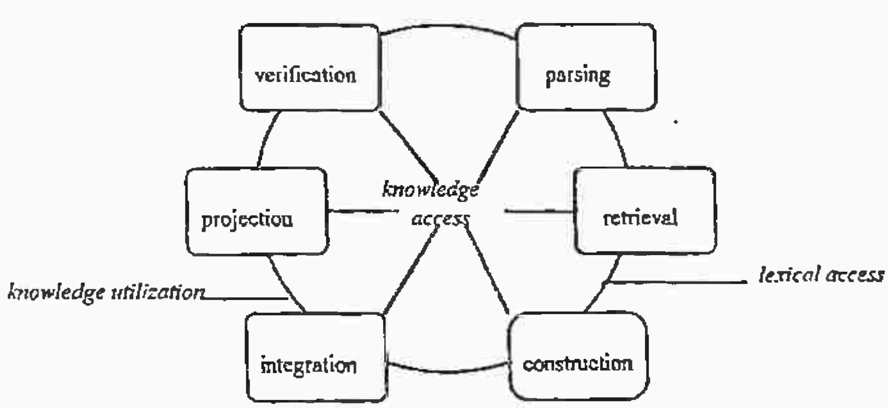
Distancing text intervening between the ambiguous stretch and the disambiguating text was found to reinforce initial scenarios. This indicates that initial scenarios are not always unequivocal. In the course of language comprehension, a positive relationship is maintained between the quality of textual information available to the processor, and the quality of accessed higher level knowledge. That is to say, when text information is ambiguous, incomplete, or absent, higher level knowledge is only hypothetical, and vice versa. Also, a self-optimizing relationship is held between textual input and higher level knowledge; in the processor's attempt to interpret the linear input of language data, the deficiency of the input text is counterbalanced by activating higher level schemata.

The results of the study also point to an intricate process of interaction between different levels of information. To characterize the nature of this process, we can assume that comprehension takes place in a cyclical fashion, and it exhibits a concatenation of six distinct stages, namely, (verification), parsing, retrieval, construction, integration, and projection. Verification refers to checking the contents of the processor against concurrent textual and contextual information. If the processor is empty, or if the contents are already validated, this stage is not invoked.

Parsing refers to the mechanical process of perceiving and segmenting oncoming language data into process units, and retrieval refers to accessing mental representations as well as textual and contextual information relevant to the process unit. Construction, on the other hand, refers to building grammatical as well as propositional (textual) units from the input text. It is during these last two stages that the process of lexical access takes place.

The process of integration refers to the establishment of a dynamic link between textual-textual, textual-contextual, and contextual-contextual information. It is at this stage that attempts at resolving incongruities take place, and, as mentioned earlier, a processes of backtracking may be involved. Finally, projection refers to anticipating structural as well as propositional units on the basis of the data available to the processor. Of course, subsequent text may be congruent or incongruent with these projections. Knowledge utilization is assumed to take place during these last two stages. Figure 5 illustrates the five stages of the comprehension process. Notice that higher level knowledge is available to the processor throughout the six stages.

Figure 5: A Proposed Model for the Interaction of Higher and Lower Levels of Information



It should be noted that this model combines some aspects of modularity with some aspects of interaction, which makes it more more suitable, and possibly more successful, in Artifical Intelligence (AI) or Natural Language Processing (NLP) applications than purely modular or extremely interactive models. It is modular in the sense that it proposes a concatenation of discrete stages for the processor in which the output of a given stage can be the input for the next one. It is also interactive as it does not assume any information encapsulation, and it allows for interaction between higher and lower level information by making higher level knowledge available to the processor all the time.

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Appendix 1: An example in Arabic of the stimulus material

١- تجنب ذلك السائل / اذا كنت لا تريد أن تضيع وقتك فيما لاطائل من ورائه/ فسوف يجحد اذا لم تغليه.

(biased, distanced, retroactive disambiguation).

٢- تجنب ذلك السائل / فسوف يجحد اذا لم تغليه.

(biased, retroactive, non-distanced disambiguation).

٣- سوف يجحد اذا لم تغليه / فاذا كنت لا تريد أن تضيع وقتك فيما لاطائل من ورائه / تجنب ذلك السائل.

(biased, distanced, proactive disambiguation).

٤- سوف يجحد اذا لم تغليه / فتجنب ذلك السائل.

(biased, non-distanced, proactive disambiguation).

٥- تجنب ذلك السائل / اذا كنت لا تريد أن تضيع وقتك فيما لاطائل من ورائه / فسوف يشتم اذا لم تعطيه .

(non-biased, distanced, retroactive disambiguation).

٦- تجنب ذلك السائل / فسوف يشتم اذا لم تعطيه .

(non-biased, non-distanced, retroactive disambiguation)

٧- سوف يشتم اذا لم تعطيه / فاذا كنت لا تريد أن تضيع وقتك فيما لاطائل من ورائه /

تجنب ذلك السائل.

(non-biased, distanced, proactive disambiguation)

٨- سوف يشتم اذا لم تعطيه/ فتجنب ذلك السائل .

(non-biased, non-distanced, retroactive disambiguation)

Appendix 2: A list of the stimulus words and their meaning bias.

Word	Meanings	Percentage of bias
ولى	fled appointed	96 4
نقد	criticism cash	100 0
مشروع	project permissible	96 4
خيار	choice best cucumber	74 22 4
سهل	easy valley	91 9
سائل	liquid beggar	71 29
تظاهر	pretence demonstration	87 13
عرض	width parade	79 21
قرن	century horn	92 8
تشكيل	diacritics formation	76 24