

LEXICAL AMBIGUITY RESOLUTION: LANGUAGES, TASKS, AND TIMING

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1. INTRODUCTION

The current work explores language, task, and timing issues in lexical ambiguity resolution. Three hypotheses are presented concerning the different results previously found for ambiguity resolution in English and Italian. The first hypothesis (language-driven hypothesis) is that the difference is language based. A strong version of this hypothesis (i.e., that context-prominent languages allow context to select the appropriate meaning of an ambiguous word) is tested with respect to lexical ambiguity resolution in Mandarin Chinese, and ruled out. A second hypothesis (speeded-selection hypothesis) is that context-prominent languages use context faster once lexical access has occurred. The third hypothesis concerns methodological issues, especially as pertains to the length of time that the visual target appears. I conclude by postulating that the key reason for the discrepancies in lexical ambiguity resolution to date are not because of cross-linguistic differences, but instead have to do with timing differences, and I suggest that experiments that adequately measure immediate, automatic lexical retrieval will demonstrate that the modularity hypothesis holds.

Language thrives on ambiguity, at both the word and sentence level. Lexical ambiguity in one way simplifies language because it allows for a language to expand its range of meanings without having to continuously add new phonological forms to its already long list of lexical items. However, lexical ambiguity at the

same time complicates language, because the processor must, upon encountering a phonological word with multiple meanings, determine which meaning is correct. Because people rarely notice that lexical ambiguities interfere with their comprehension of a speaker's utterance, lexical ambiguity resolution must occur before a listener consciously notices it—that is, it must occur very, very quickly. There are two basic theoretical models of lexical ambiguity resolution: context-dependent models and context-independent models. A context-dependent account postulates that the context that precedes an ambiguous word will aid the processor in accessing only the contextually appropriate meaning, and the contextually inappropriate meaning will not be accessed. A context-independent account says that the preceding context will not be able to influence which meaning is accessed at an ambiguous word. The context-dependent model is compatible with a language-processing account that says that information among different language subsystems (such as lexical access and discursal knowledge) can interact in ongoing language processing at any point in time (e.g., McClelland, 1987). The context-independent model is compatible with a modular language-processing account (Fodor, 1983). Under a modular view of language processing, processing must be completed in one language subsystem (such as lexical access) before information from another language subsystem (such as discursal knowledge) can influence the results. Thus, the implications for lexical ambiguity resolution extend not only to the nature of the language-processing system, but also to the makeup of the underlying cognitive architecture that support language.

In this chapter I first discuss the evidence that pertains to each model, and then point out that lexical ambiguity resolution must be looked at within the paradigms of natural speech comprehension and reading comprehension separately in order to better understand the nature of lexical access. Next I point out that the findings in lexical ambiguity resolution differ along language lines, and postulate a hypothesis that accounts for this fact. I then test this hypothesis, and at the same time test the context-dependent hypothesis, and find that neither hypothesis holds. I revise the original language-driven hypothesis, and also suggest other methodological reasons for the discrepancies in the English and Italian results.

2. CONTEXT-DEPENDENT AND CONTEXT-INDEPENDENT MODELS

I distinguish and discuss two types of context-dependent models: a "strictly" selective account and a "modified" selective account. A strictly selective account says that context alone is enough for the processor to select the appropriate meaning of the ambiguous word (e.g., Glucksberg, Kreuz, and Rho, 1986; Simpson, 1981). This means that if the context is biased towards the dominant meaning of a word, then only the dominant meaning is accessed. Moreover, if the context is biased toward the subordinate meaning of a word, then only the subordinate mean-

ing is accessed. In effect, context can block the access of the noncontextually appropriate meaning, and select only the meaning that is contextually appropriate.

A modified selective account says that when context and dominance (frequency of meaning of the lexical item) interact, only the contextually appropriate meaning of a word is selected (e.g., Tabossi, Columbo, and Job, 1987; Tabossi, 1988; Tabossi and Zardon, 1993). The prediction of the modified selective account is as follows:

When the contextually congruent meaning is also the dominant one, the subordinate meaning . . . receives some initial activation from the perceptual input, but this may never become strong enough to be detected by current experimental methodologies. Instead, when context constrains the subordinate meaning, the activation received from . . . the dominant meaning is still sufficient to render it detectable, so that both meanings will result [in being] reliably active. (Tabossi, 1993:369)

This account "conceptualizes access as a continuous event which is accomplished when semantic information about a word is sufficiently activated to be integrated, when appropriate into prior discourse" (Tabossi, 1993:369-370).

There are two types of context-independent models: one version is known as an exhaustive or a multiple-access model. This model predicts that all meanings will be immediately accessed regardless of the sentence's contextual bias, or the relative frequency ranking of the meanings (e.g., Swinney, 1979; Onifer and Swinney, 1981). This finding holds irrespective of whether the contextual bias is toward the primary or secondary meaning of the word. However, after lexical access has occurred, and by 1500 ms downstream, only the contextually appropriate meaning is left available (e.g., Swinney, 1979; Tanenhaus et al., 1979; Onifer and Swinney, 1981; Swinney and Love, 1996). The interpretation is the following: "Lexical access appears to be an exhaustive and autonomous subroutine of the sentence comprehension process (autonomous in the sense that it does not appear to be driven or guided by previously occurring semantic information)" (Onifer and Swinney, 1981, p. 232).

Another version of the context-independent model postulates that the order of access of word meanings is related to their frequency ranking (Hogaboam and Perfetti, 1975). That is, regardless of the contextually appropriate meaning, the most common meaning will first be retrieved and tested for its compatibility with the context. If it is found to be incompatible, then the next meaning is retrieved and tested, until a match is found. An ordered access model predicts that if the context is biased toward the most frequent meaning, that will be the only meaning that is retrieved, but if the context is biased towards a less frequent meaning, then the contextually biased meaning and all more frequent meanings will be retrieved.

Note that this model makes the same predictions as the modified selective-access account does for words with two possible meanings, although the models on which they are based are completely different. In both models, if the context

is biased toward the dominant meaning, the dominant meaning is activated, and if the context is biased towards the subordinate meaning, then both the dominant and subordinate meanings are activated. In cases where there are more than two meanings, it is possible that the modified selective access account will again make the same prediction as the ordered access account; namely, if any subordinate meaning is picked, all more dominant meanings will also be accessed. However, the modified selective access account could also predict that only the contextually appropriate subordinate meaning (e.g., M4, the fourth meaning), and the most dominant meaning (e.g., M1, the first meaning) will be accessed. Given Tabossi and Zardon's definition above, the question revolves around whether or not the more dominant (but not contextually appropriate subordinate meanings (e.g., M2 and M3)) have enough activation to be detectable. This conceptualization of the modified selective access could potentially differentiate it from the ordered access model, because an ordered access model does not concern itself with level of activation (although it could easily incorporate this concept).

However, what is crucial for the discussion at hand is that the modified selective access model is (under either conceptualization) still a context-independent model (although Tabossi and colleagues originally postulated otherwise), because context does not select a meaning. Instead, all meanings are activated (i.e., "When the contextually congruent meaning is also the dominant one, the subordinate meaning . . . receives some initial activation from the perceptual input, but this may never be strong enough to be detected by current experimental methodologies"—Tabossi, 1993:369). Whether or not the activation can be detected is a separate, methodological issue. The theoretical issue is whether preceding context does or does not select a single, appropriate meaning. Since the modified selective access account does not, and since it postulates activation of all meanings, it is an account that exists within the context-independent model.

3. NATURAL SPEECH COMPREHENSION

In the preceding section, I argued that the modified selective access account should be viewed as being within the context-independent model. Even so, there is still evidence for the context-dependent view. In fact, the question as to why evidence can be found for both models has perplexed researchers working on lexical ambiguity resolution for the past two decades.

Simpson (1994) reviews the relevant empirical studies on lexical ambiguity resolution and concludes that there are no clear methodological reasons as to why different studies have supported different models. The methodological variations he considered include (a) method of presentation of the context (either auditory

or visual); (b) type of task (such as lexical decision or naming or Stroop); and (c) location of the ambiguity within the context sentence (sentence-medially or sentence-finally).

However, it could be the case that the question he is attempting to answer, given in (1) below, is too broad to allow a unified explanation.

- (1) "To what extent do higher level semantic representations, such as those arising from the processing of a sentence, constrain the activity of a lower process (in this case the identification of a word)?" (Simpson, 1994: 359)

If instead we begin with a different and narrower question, as stated in (2), and look at the studies that pertain to this question, we will find that the reasons for the differences can be explained.

- (2) To what extent do higher level semantic representations constrain the activity of a lower process (in this case the identification of a word) in natural speech comprehension?

Question (1) refers to any type of comprehension process (i.e., reading, listening, or signing comprehension). However, it is not clear that it is appropriate to conflate the different modalities, because (a) there are different areas in the brain that deal with auditory and visual stimuli; (b) speech (or sign language) is learned earlier than reading; and (c) that speech (or sign language) is the basis for learning how to read. Under these assumptions the time course of lexical ambiguity resolution in reading comprehension is a different question from that of lexical ambiguity resolution in speech comprehension and should be examined separately.^{1,2}

When we narrow our focus to lexical ambiguity resolution in speech comprehension, we naturally need to look at cross-modal experiments. Cross-modal priming experiments involve subjects listening to a sentence (spoken by a native speaker at normal speed) over headphones and making either a lexical decision to a visual target that appears on the screen (cross-modal lexical decision task) or naming the visual target (cross-modal naming task). The visual target usually appears at the offset of the ambiguous word, but there is no pause in the sentence that the subject is hearing—she or he hears a complete and natural-sounding sentence. This type of technique is advantageous to studying the time course of language processing (a) because subjects are listening to natural speech as they would in nonexperimental settings; (b) because the presentation of the visual target can be precisely controlled in order to see the time course of ambiguity resolution; and (c) because the task (either naming or lexical decision to the visual target) does not require conscious reflection on the nature of possible relationship between the information they are hearing over the headphones (i.e., the ambiguous word) and the visual target (i.e., a semantic prime or a control word) (Nicol, Fodor, and Swinney, 1994; Swinney and Love, 1996).

When we concentrate on question (2) and review the work on cross-modal lexical ambiguity resolution experiments, we find that there are, indeed, methodological reasons as to why some researchers report findings for the strictly selective access model (Simpson, 1981; Glucksberg et al., 1986), the modified selective access model (Tabossi et al., 1987; Tabossi, 1988; Tabossi and Zardon, 1993), as well as the multiple access model (Swinney, 1979; Tanenhaus et al., 1979; Onifer and Swinney, 1981; Seidenberg et al., 1982; Swinney and Love, 1996). The areas we will look at include (a) position of visual target; (b) experimental task; and (c) language.

The position of the visual target in relation to the ambiguity is of paradigmatic importance in understanding the time course of ambiguity resolution. As a number of researchers have pointed out (McClelland, 1987; Onifer and Swinney, 1981; Simpson, 1994), intervals that occur between the offset of the ambiguous word and the presentation of the visual target mean that the activation is not indicative of immediate processing. One cross-modal study that found evidence of strictly selective access (Simpson, 1981) presented the visual target with a delay from the offset of the ambiguity at 120 ms. These findings might, in fact, represent the effects of context once the word has been accessed, and cannot be construed as supporting a model of selective access.

The other cross-modal experiment found for strictly selective access was a cross-modal interference task with pseudowords. In Glucksberg et al.'s (1986) experiment, subjects were presented the visual target at the offset (0 ms) of the ambiguity, but the visual targets of the ambiguous words were all pseudowords. The idea was that the subjects would be slower to reject them as nonwords, because the pseudowords would remind subjects of related words. However, it is not clear that this interference task was measuring processing relating to ambiguity resolution, nor is it clear that the interference task allowed a decision that was within the time window of lexical access. (Please see Pr ather and Swinney (1988) for a discussion of these and related issues.) More importantly for our discussion here, an interference task with pseudowords has not been used in any other cross-modal lexical decision task for ambiguity resolution, and thus it is difficult to ascertain if the finding for selective access has to do with the fact that it was a different type of task (i.e., an interference task with pseudowords).

Thus, the cross-modal on-line sentence-processing data in support of a strictly selective account is limited, and involve timing and task issues that make it difficult to ascertain if the findings were artifacts of these issues. Because findings for a strictly selective account would be the clearest indicator that language processing is an interactive (as opposed to modular) process, we will test this hypothesis in Mandarin Chinese. The reason is that, as we will explain in the next section, Mandarin is a language that relies heavily on contextual information in order to arrive at linguistic interpretation, and is most likely to support a strictly selective account.

I turn now to the three works that find for a modified selective access account in a cross-modal priming paradigm, which are all in Italian (Tabossi et al., 1987; Tabossi, 1988; Tabossi and Zardon, 1993). When I compare these three experiments, which all find that context and dominance can influence lexical access, with experiments that have found that context and dominance do not influence access (Swinney, 1979; Tanenhaus et al., 1979; Onifer and Swinney, 1981; Seidenberg et al., 1982; Swinney and Love, 1996), I find that they are similar on several methodological counts: they all are cross-modal tasks (either naming or lexical decision); they all have the visual target appear immediately at the offset of the ambiguous word; and they are all priming tasks (as opposed to the interference task with pseudowords that Glucksberg et al., 1986, used). In the Italian experiments, the ambiguities occur sentence-medially, whereas in the English experiments the ambiguities occur either sentence-medially or in the sentence-final position.

The main methodological differences between the two groups of experiments are the following: first, the languages in the experiment are different; second, the lexical decision tasks are different (i.e., in the Italian case a go/no-go paradigm is used. This means instead of the usual task of pressing one button if the visual target is a word, and another button if it is a nonword, subjects only press a button if the visual target is a word, and do nothing otherwise.) Third, the presentation of the visual target in the Italian experiments is 1500 ms, whereas in the English experiments, the presentation of the visual target is never more than 1000 ms.

In what follows I will first explore the hypothesis that the difference in findings derives from the different linguistic properties of English and Italian. I will present an experiment that tests the strongest form of this hypothesis, and show that it does not hold. This experiment will, at the same time, test for the strictly selective access account. To foreshadow the results, the evidence will demonstrate that neither hypothesis is correct. In the general discussion section I will return to the two methodological possibilities as alternatives for the differences in the findings.

4. LANGUAGE-DRIVEN DIFFERENCES

If it is the different linguistic properties of English and Italian that are driving the difference in lexical ambiguity resolution results, this would lead to a near-Whorfian conclusion that native languages shape how we process that language, and that there is no universal language processor. This would imply that the underlying cognitive wiring for language processing in Italian and English is very different. What could be the reason that Italian allows a combination of context and dominance to influence lexical access, while English does not?

English has an impoverished agreement system, which means that it relies more heavily on structural information for semantic interpretation (i.e., in English the

subject position is often the agent of the action, and the object position is often the patient of the action). In addition, English does not allow the omission of either the subject or the object. Italian has a richer agreement system, which means that the referents are often determined by the agreement markers on verbs and not necessarily by an overt noun. Italian also allows the dropping of the subject to occur. Thus, Italian is a language that requires more information to be recovered from context than English, because in Italian the referents can be missing, whereas English relies on overt referents that have a reliable syntactic-semantic association. A language-driven hypothesis would suggest that because contextual information is crucial to interpreting the incoming string of information, it is also available and able to influence lexical access. The language-driven hypothesis is formulated as in (3).

- (3) Language-driven hypothesis: If a language is context-prominent, then context will be able to influence lexical access immediately and automatically.

A language is defined as being context-prominent if contextual information plays a prominent role in interpreting a sentence. For example, languages that allow dropping of the subject, or of the object, need context in order to interpret the missing information.

One way to test the language-driven hypothesis is to look at ambiguity resolution in a language that relies even more heavily on contextual information than Italian. Mandarin Chinese is one such language.³ Mandarin Chinese is like English in that it has an impoverished agreement system, but more like Italian in that it is a prodrop language. In fact, in Mandarin both the subject and object can be omitted in situations where context allows the information to be reconstructed. For example, if someone asks, "Do you like ice cream?" or "Do you like the ice cream I bought home from the store yesterday?", one can respond to either question with a simple "Like." In Mandarin, the previous sentence is enough to "fill in" for both the speaker and the hearer who is doing the liking, and what is liked.

Moreover, even though in Mandarin subjects and objects are structurally encoded as in English, when topicalization occurs, a subject and object can switch their surface position without changing the dominant interpretation, as shown in (4) and (5) (Huang, 1985).

- (4) *Zhe zhong cong, niao chi de hen duo.*
This type bug, bird eat DE very many
'Birds eat a lot of this type of bug.'
- (5) *Zhe zhong niao, cong chi de hen duo.*
This type bird, bug eat DE very many
'This type of bird eats a lot of bugs.'

In (4) and (5), both participants occur preverbally, even though in reversed order. The dominant interpretation of both sentences is semantically equivalent,

with 'cong' (bug) interpreted as the preposed object in each case. As for 'niao' (bird), it occurs in the canonical subject position in (4), and is interpreted as the preposed subject in (5). Thus, in Mandarin structural information alone does not reliably determine the semantics of the proposition.⁴

From the above discussion we see that Mandarin Chinese relies on contextual information to assign interpretations, instead of structural information that may either be missing or unreliable. In this respect it is even more context-dependent than Italian, which is already more context-dependent than English. If the language-driven hypothesis is correct, the reason that Tabossi and colleagues found context and dominance influenced ambiguity resolution in Italian could be because Italian is more dependent on contextual information for propositional interpretation to take place. Furthermore, if the language-driven hypothesis is viable then context should influence ambiguity resolution in Mandarin Chinese because Mandarin relies even more heavily than Italian on contextual information for semantic and propositional interpretation.

The following experiment will test this hypothesis in its strongest form because we will look at the effect of context alone. I will test for the activation of both meanings at the onset position when the sentential context is biased toward the secondary (subordinate) meaning of the ambiguity. I select the onset position in order to rule out the possibility that a meaning was accessed but then faded. I bias toward the secondary meaning because this is the strongest test for a hypothesis, which postulates that top-down information can influence lexical access (e.g., the strictly selective access account). If I find that only the contextually appropriate meaning is accessed, then the language-driven hypothesis will become more plausible. It will also be the first time that evidence for a strictly selective account is found in an on-line cross-modal priming paradigm. If this is indeed the case, it will then be important to look at the position of the visual probe point in order to make sure that the lexical item was recognized. If I find both meanings accessed, it will mean that the strong language-driven top-down hypothesis did not hold, and that the strictly selective access account once again did not receive empirical support from an on-line sentence comprehension paradigm. It will also mean that the onset position was not too early to see an activation from either the contextually appropriate or contextually inappropriate meaning.

5. EXPERIMENT: LEXICAL AMBIGUITY RESOLUTION IN MANDARIN CHINESE

5.1. Subjects

All subjects were native speakers of Mandarin Chinese, had lived in Taiwan since birth, and were undergraduate or graduate (M.A.) students of National Chung Cheng University (NCUU), in Chia-yi, Taiwan. In Taiwan, there is usually

another language spoken in the home in addition to Mandarin, such as Taiwanese, Hakka, or an Austronesian language. Therefore, in order to keep the subject pool as homogeneous as possible in terms of language background, all subjects used in the following experiments were exposed not only to Mandarin but also to Taiwanese in the home before the age of 7. They were also screened for any brain injury, learning disability, or other abnormal mental behavior. All subjects were paid for their participation. The actual number of subjects used in each pretest or experiment are given in each of the appropriate sections below.

5.2. Pretest for Ambiguity Bias

Thirty NCCU undergraduates were presented with 90 words (52 nouns, and 38 verbs) that had at least two meanings. Presentation was auditory, because words often have different auditory and visual biases. For each word, subjects were asked to provide the first meaning they could think of, and then they were asked to provide another meaning if they could think of one. Tallies of the numbers of first and second choice for each meaning of the words were made. For the present study 16 nouns were chosen that had a preference for a primary interpretation (i.e., the chosen primary meaning had to have been listed as the first-choice meaning for speakers over 75% of the time); additionally, the secondary meaning had to have been listed as the second-choice meaning for speakers over 60% of the time.

5.3. Pretest—A Priori Equated Reaction Times for Experimental and Control Probes

Probes for the Primary and Secondary meaning of the ambiguity were chosen by using one of the three most frequently provided associates, with the restriction that if these associates were not disyllabic, a disyllabic word closely related to the most frequent associate was used. A large number of words equated to the “related” associates on the basis of frequency, length, and form class were included with the experimental/related associate words in an isolated lexical decision task. Twenty subjects participated in this experiment. After the average for each word was calculated, a “matched” control word was chosen for each “related” associate for each meaning of the ambiguity. Overall, the mean reaction times for the primary experimental and control condition was 483 ms and for the secondary experimental and control conditions was 467 ms. In addition, the experimental and control conditions were matched across individual items for syllable length, and the frequency of the control conditions was always higher than for the experimental conditions overall, which works against my hypothesis (since higher frequency words are more likely to be accessed more quickly). The frequency data was based on written norms (CKIP, 1993).

5.4. Creation and Pretest of Sentential Materials

Each ambiguous word was placed in a sentence biased toward its secondary meaning. Subjects were given the actual experimental sentence up to the point just before the ambiguity and asked to complete the sentence. Following Tabossi's criteria for creating a bias towards a "strong" aspect of one meaning of the ambiguity, at least 75% of 21 subjects agreed on the intended aspect of the contextual bias. An example is given in (6a) below. The experimental and control visual targets for the primary and secondary meanings are given in (6b).

(6) a. *tonghua gushi li de wangzi ru yao yingqiu bei kun zai chengbao*
 fairy tale story in DE prince if want win BEI confine in castle

nei de gongchu shi ta bishu guo chongchong de jiguan cai neng
 in DE princess when he must pass multiple-level DE trap then can

cong ermo shou zhong qiu hui ta de xinshangren, yushi congci
 from devil hand middle rescue back he DE loved-one then from

yihou guo zhe xinfuquailie de rezi.
 after live particle happy DE days

'In a fairy tale, when a prince wants to rescue a princess that is locked up in a castle, he must overcome serious traps in order to rescue the one he loves from evil, so that the two of them can live happily ever after.'

b. ambiguous word: *jiguan*

	Experimental visual target	Control Visual target
primary meaning (institution)	<i>xingchen</i> 'administration'	<i>xiaoshi</i> 'hour'
secondary meaning (trap)	<i>xianjin</i> 'trap'	<i>shumian</i> 'report in writing'

The entire experiment consisted of 42 sentences: 16 experimental sentences and 26 filler sentences. All sentences were recorded by a female speaker to the hard drive of an IBM-compatible Pentium computer with the aid of the Creative Wave sound card using the Creative Wave program. The time from the beginning of the sentence to the onset of the ambiguity was measured using the same program. This information was then entered into a control list that associated the time of presentation along with each respective sentence and visual target. At the time of the onset of the ambiguity, a visual target was flashed on the screen for 300 ms. An internal dedicated CPU in the button box measured the time from the presentation of the visual target until a response was made on the button box or 2000 ms had passed, whichever was earlier. The program controlled for timing problems in video display, such as raster position. The measurements of the dedicated CPU are accurate to the thousandths of a millisecond (.001 ms). The measurements themselves were made to the nearest millisecond. The sentences occurred in random order, and there was a 5-sec delay between sentences.

5.5. Procedure

Subjects sat in front of a computer monitor in a sound-attenuated booth and were told that they had two tasks. The first task was to listen and understand the sentences that they heard. They were told that they would be tested on the comprehension of the sentences at the end of the experiment. They were also told that they had a second task—to watch the computer screen and when they saw characters appear on the screen to decide if the characters made up a word or not. They were told to press the right-hand button (marked “word”) as fast as possible if they thought it was a word, and to press the left-hand button (marked “nonword”) if they did not think it was a word. They were asked to keep their fingers directly on the buttons at all times. The auditory sentence continued on without interruption even when the visual probe was being presented and the subjects were making their decision. Each subject’s attention was focused on the middle of the screen by means of a black mask that allowed only a small word-sized area of the screen to be visible. At the end of the cross-modal portion of the experiment, the subjects were given 10 sentences printed on a sheet of paper and asked to mark which sentences they had just heard.

5.6. Results

Subjects were screened for errors on an individual basis. Subjects with errors greater than 15% on the lexical decision task (i.e., more than six wrong) and those with errors above 20% on the comprehension test (i.e., more than two wrong) were dropped from the analysis. After screening for errors, there were 48 subjects with reliable data. Table 1 presents the mean reaction times of correct responses in each condition. The overall variance of data was run on individual subjects data employing Lists (4) as a between-subjects factor (materials counterbalancing factors) and Ambiguity Meaning (Primary and Secondary) and Probe Type (Related and Control) as within subjects factors. An overall significant main effect of Meaning ($F(1,44) = 7.42, p < .009$) and Probe Type ($F(1,44) = 14.49, p < .001$) was found.

TABLE 1
MEAN REACTION TIMES (IN MILLISECONDS) FOR RELATED AND CONTROL PROBE LEXICAL DECISION TIMES FOR BOTH PRIMARY AND SECONDARY MEANINGS OF THE AMBIGUITY

Meaning of ambiguity	Probe type	
	Related	Control
Primary	622*	651
Secondary	576*	642

*significant difference between related and control contrast. See text for details.

These effects were further examined via a priori planned (1-tailed) comparisons of the Probe Type condition (Related vs. Control Probes) for each of the Ambiguity Meaning Conditions (Primary and Secondary). There was significant priming for the related (compared to control) probes for the Primary meaning ($F(1,44) = 3.01, p < .045$), as well as for the Secondary meaning ($F(1,44) = 17.78, p < .001$).

5.7. Discussion

When occurring in a context that constrains its subordinate (or secondary) meaning, an ambiguity primes a visual target associated both to the dominant (or primary) meaning, as well as the subordinate meaning. This means that neither the strictly selective account nor the strongest form of the language-driven hypothesis holds. Thus, even though context plays a very important role in propositional interpretation in Mandarin, the language processor does not give context special priority with regards to determining the meaning of an ambiguous word.

5.8. General Discussion

Even though Mandarin Chinese is a language in which context plays a critical role in sentential interpretation, context alone is not enough to influence lexical access. Thus, the language-driven hypothesis, as formulated in (3) above, does not hold. It is not the case that if language is context-prominent, context can, in turn, influence lexical access in that language. It remains to be seen if, and how, other linguistic properties of a language necessitate different language-specific processing mechanisms.

I also did not find evidence to support a strictly selective access account. When I biased the context towards the secondary meaning of the ambiguous word, both the primary and secondary meaning were facilitated relative to their respective controls.

This is evidence against an interactionist model of language processing, which postulates that information in one module can influence information in another module before or while the information in the latter module is being processed. At this point then, there is no evidence for an interactionist view of lexical access in ongoing natural speech comprehension.

The only evidence there is to date for a modified selective access account is in Italian. In the introduction I pointed out the modified selective account made the same predictions as the ordered access account, which were that when the sentence is biased towards the dominant meaning of the ambiguity, only the dominant meaning is accessed, but when the sentence is biased towards the subordinate meaning of the ambiguity, both meanings are accessed. This prediction is compatible with a context-independent model because it could be the case that context was ignored, and the most common meaning was retrieved first, and then if that wasn't compatible, the next most common meaning is retrieved.

Thus, the question at this point is no longer whether lexical access is influenced by context, because it is not, as is clearly shown from this experiment. Lexical access occurs independently of context. The question is in a language where context plays an important role (as in Italian and Mandarin), can the combination of context and dominance influence lexical access? There is a recent cross-modal lexical ambiguity resolution study in Cantonese, which addresses this question (Li and Yip, 1996).

Li and Yip created contexts for both the dominant and subordinate meaning of the ambiguity and ran a cross-modal lexical naming task where the ambiguity occurred sentence finally. They found that both meanings of an ambiguity were accessed when the visual probe was presented at the onset of the ambiguity, but that only the contextually appropriate meaning was accessed when the visual probe was presented at the offset of the ambiguity. These results held when the sentence was biased toward either the dominant or subordinate meaning of the ambiguity. Their interpretation is as follows:

Our results from the Onset . . . condition seem to suggest that there is a very brief moment of lexical access of multiple meanings following the onset of the acoustic signal. However, this moment is short-lived and other information such as frequency could start to play a role rapidly thereafter. (Li and Yip, 1996, p. 231).

Cantonese is mutually unintelligible with Mandarin, although they both share the same writing system. However, Cantonese does share the same characteristics of an impoverished agreement system, and subject and object omission, although it differs from Mandarin in that the subject and object position are more straightforwardly related to the agent and patient of a sentence, as in English. (That is, sentence (5) above is considered strange in Cantonese [Hintat Cheung, personal communication, January 1997]). Thus, Cantonese also relies on context to interpret the meaning of a sentence, although perhaps not to the extent that Mandarin does, but certainly more so than English.

Li and Yip's findings are interesting for three reasons: first, they also do not support the language-driven hypothesis; that is, in Cantonese, which is also a context-prominent language, both meanings are always accessed first, and then the contextually appropriate meaning is selected. Second, their findings support a multiple-access account over a strictly selective or modified selective account, because both meanings were accessed at the onset position irrespective of the contextual bias. Third, Li and Yip found that context alone (even in the subordinate case) was enough to influence the result of lexical access at the offset of the ambiguity, which differs from what was found for Italian. The possibility then exists that it is because Cantonese is sensitive to contextual information that drives language processor to decide on the contextually appropriate reading as soon as the offset of the ambiguity. That is, lexical access is a modular and bottom-up

process, but the fact that Cantonese relies on context so heavily forces the processor to choose between the ambiguous meanings faster than it does for Italian. Italian, in turn, relies on context more than English, and so the interaction of context and dominance contains enough information to allow the selection between ambiguous senses faster than in English. This, if true, would support a modified language-driven hypothesis, given in (7).

- (7) Speeded-Selection hypothesis: If a language is context-prominent, then the language processor will select the contextually appropriate meaning faster (once all meanings have been accessed) than it would in languages that rely less heavily on context for interpretation.

The speeded-selection hypothesis differs crucially from the language-driven hypothesis in that it is not the structure of the language that affects the interpretive process. Instead, it is the processing strategy that affects the interpretive process. In other words, context-prominent languages may select contextually favored meanings faster because the contextual processing routine is performed much oftener in the language. Familiarity in the processing regime allows for quicker processing time.

In addition, this hypothesis does not conflict with a context-independent account, because it assumes a modularly designed language-processing system. What this hypothesis does do is explain why Italian and Cantonese allow context to play a role so much faster than it does in English. But before we jump to this conclusion, we need to examine what else could possibly be different among the Italian, Cantonese, and English experiments. Methodological differences may be what is driving the difference in results among the different experiments.

The task used in Italian was a go/no-go lexical decision task. That means that if the subjects decided that the string of letters flashing on the screen was a word, they pressed a button, but if they decided it wasn't a word, they did nothing. This task is different from the usual task of pressing one button if they see a word, and another button if they don't. The go/no-go task might lead to hesitancy on the part of the subject because they must hold back from performing an action when making a nonword decision. Instead of automatically performing an action as soon as they make a decision they must then remember not to perform an action. This could inhibit the automaticity of the decision. This is relevant to the modularity hypothesis because the modularity hypothesis assumes that only tasks that reflect the automaticity and immediacy of lexical access will not allow preceding information to influence lexical access (Fodor, 1983). Anytime that automaticity or immediacy is compromised, there is the possibility that other information could have interfered with access. However, if we follow this line of reasoning, then it is not immediately apparent why Cantonese, which used a naming task, found that context influenced lexical access more quickly than in English (i.e., at the offset of the ambiguous item). Naming tasks have been used in experiments that

have found for the context-independent hypothesis (i.e., Swinney and Love, 1996; Seidenberg et al., 1982; Tanenhaus et al., 1979).

Moreover, the naming task used seems to be consistently automatic in that only words are flashed on the screen, and the subjects are asked to immediately pronounce whatever word they see. There is no reason to hesitate in this type of task. (If, however, both words and nonwords flashed on the screen, and the subjects were asked only to name the words, then the task would involve the same hesitancy as the go/no-go lexical decision task.) Thus, it does not appear that the issue of automaticity can straightforwardly account for the differences in results that we find for Cantonese, Italian, and English.

This brings us to the other critical methodological point—the issue of immediacy. The timing of the ambiguity resolution is critical to understanding lexical access. We have already pointed out in the introduction (and others have noted previously) that even a slight delay in the presentation of the visual target could mean that context was selecting a meaning after both meanings were already selected. In addition to the position point of the visual probe, there is another timing issue that to date has been overlooked, to the extent that its value is sometimes not clearly given in the methodology section. The timing issue we are referring to is the length of presentation of the visual probe. In Italian the visual probe appeared for 1500 ms (Tabossi, Columbo, and Job, 1987; Tabossi, 1988; Tabossi and Zardon, 1993), and in Cantonese it seems that the probe appeared for 2000 ms (“A visual probe then occurred on the computer screen. . . . Subjects were given a maximum of two seconds to respond, counting from the onset of the visual probe”; Li and Yip, 1996, p. 229). The experiments in English, however, never had the visual probe appear for more than 1000 ms (Onifer and Swinney, 1981), and was as short as 300 ms (Swinney and Love, 1996). It is difficult to ascertain if the length of response time in the Italian and Cantonese experiments was significantly longer than the response time to visual targets in English, but that is not what is at issue here. Obviously, the average length of response times to visual targets could differ across languages. What could be critical is that the subjects in the Italian (Tabossi, Columbo, and Job, 1987; Tabossi, 1988; Tabossi and Zardon, 1993) and Cantonese (Li and Yip, 1996) experiments see the visual target until they make a decision or the outer limit of time (either 1500 ms or 2000 ms) is reached. It is quite possible that when the visual target is presented at the offset of the word, and up to 1500 ms (or 2000 ms) is allowed to pass, context is able to influence the choice after modular lexical access has already occurred. In the cases—as in English (Swinney and Love, 1996) and Mandarin (see previous section)—where the visual target only flashes onscreen for 300 ms, the immediacy of making the decision is more pronounced. Again, since the modularity hypothesis assumes that immediate and automatic access is taking place, one must be sure that one is, in fact, measuring immediate and automatic access.

In addition to the concerns of immediacy and automaticity, other methodologi-

cal details should also be considered carefully. These include making sure the context is biased in a strong enough manner (Tabossi et al., 1987), and making sure that the experimental and control visual targets are equated in terms of a priori reaction times, and balanced for in terms of frequency and length. Also, to avoid the possibility of wrap-up effects, it is probably prudent to place the ambiguity in a sentence-medial position. The sentence-medial position also is a better test of ongoing processing. When the ambiguity occurs sentence-finally, the decision to the visual target actually occurs after the sentence ends. Only when all relevant factors, such as immediacy and automaticity of access, as well as other methodological issues, have been controlled for, will the theoretical questions concerning the lexical access of ambiguous words be resolved.

In sum, the possibility exists then that the reason that selective access is found in Cantonese (Li and Yip, 1996) and Italian (Tabossi, Colombo, and Job, 1987; Tabossi, 1988; Tabossi and Zardon, 1993) at the offset position is (a) either because these languages are more sensitive to context effects than English (and so context influences the result of multiple-lexical access faster), or (b) because the visual probes appear on the screen long enough for context effects to choose between the meanings provided.⁵ If the first possibility is correct, then the Speeded-selection hypothesis stands. If the second possibility is correct, then when the visual probes appear for a shorter amount of time, both meanings should be accessed even when biased towards the dominant meaning, which would mean that the Speeded-selection hypothesis would not receive support. In either case, though, multiple access still occurs. In order to rule out multiple access, one has to show that context influenced lexical access at the point where the word is identified (which may be earlier than the actual end of the word itself) and also that it occurred within an appropriate time frame (i.e., the visual target occurred for only 300 ms at the identification point), and all other relevant methodological factors have been controlled for.⁶ In order to rule out the context-dependent account, one has to show that in a strongly biasing context, both (or all) meanings are still accessed at the identification point of the word (again with all the relevant methodological factors controlled for). This has been demonstrated for Mandarin (when the context is biased towards the subordinate meaning) and has also been demonstrated in English and Cantonese. It remains to be shown in other languages.

6. CONCLUSION

This work points out that there is no evidence for a context-dependent, interactionist account of lexical access within the paradigm of natural speech comprehension. I also argue that the findings for a modified selective access account are

(a) actually accountable for within a context independent framework, and (b) limited to Italian. Given the fact that the findings to date for lexical ambiguity resolution differ along language lines (i.e., in English both meanings are always immediately accessed—multiple access—whereas in Italian if the context is biased towards the dominant meaning, only that meaning is accessed—modified selective access), I hypothesize that there is something unique to the language that drives the processing differences (e.g., language-driven hypothesis).

I examined this hypothesis by looking at a language, Mandarin Chinese, that is noted for its reliance on context for semantic interpretation. I presented findings from a cross-modal lexical decision experiment and demonstrated that both meanings of an ambiguity are semantically primed, which shows that even in a language that relies heavily on context, context alone cannot influence lexical access. Thus, there is no support for the language-driven hypothesis. The experiment, moreover, clearly demonstrated that there is no evidence within a cross-modal priming paradigm that supports a context-dependent account of lexical access in language processing.

Two possibilities were put forth to explain the reason why multiple access occurs in English, regardless of the contextual bias, but not in Italian. One possibility is given in the speeded-selection hypothesis, which postulates that context-prominent languages (such as Italian), will allow context to select a meaning (once all meanings have been accessed) faster than in languages that are not as context prominent (such as English). Another possibility is that the length of presentation of the visual target is another timing factor that is crucial to understanding the time course of lexical ambiguity resolution. If the length of the visual presentation of the target is too long, the immediacy and automaticity of lexical access may be compromised. In addition, methodological details should be controlled for as tightly as possible, including controlling for equality of reaction times of groups of visual targets, similarity in task and sentential position, pretesting that a context is strongly enough biased, and so on. Future research in lexical ambiguity resolution will benefit from limiting the scope of inquiry to one area of language comprehension at a time, ascertaining the relevance of the relative context-prominence of a language, and examining issues relating to the automaticity and immediacy of lexical access.

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NOTES

¹Even though unimodal (reading) experiments have found for both the selective (Simpson and Krueger, 1991; Paul et al., 1992) and multiple-access models (Kintsch and Mross, 1985; Till et al., 1988), the reasons for the discrepancies in these cases might be related to the method of visual presentation, the time course of the presentation, the reading span and/or reading level of the subjects, or the task. For example, both Kintsch and Mross (1985) and Till et al. (1988) used a Rapid Serial Visual Presentation method in which the words appeared one at a time in the center of the screen. Simpson and Krueger (1991), on the other hand, used a paradigm where the entire sentence was presented, and Paul et al. (1992), used a RSVP method where the sentence appeared to “unfold” across the screen from left to right. Thus, the reasons for the difference in results should be looked at within the methodological constraints of the unimodal experiments, and should not be mixed in at this point in time with cross-modal experiments that are examining lexical ambiguity resolution in ongoing speech comprehension.

²Signing comprehension is an interesting case because it shares characteristics with both reading comprehension and speech comprehension. It shares with reading the fact that it occurs in the visual modality, but it shares with speech the fact that it is used for communicative purposes with other speakers, is learned earlier than reading, and is the basis for learning how to read.

³Mandarin Chinese is the official governmental language that is spoken throughout China and Taiwan by the majority of speakers, who may in addition speak another regional

Chinese language at home. In this chapter, I focus on the Mandarin Chinese that is spoken in Taiwan.

⁴In addition, Ahrens (1994) demonstrated that the syntactic phenomenon of *wh-in situ* extraction over islands in Mandarin (at the level of Logical Form) depended not on a syntactic argument/adjunct asymmetry, but instead had to do with whether or not there was a possible set of referents accessible to the speaker and hearer. This is an example of semantic information determining syntactic behavior and propositional interpretation.

⁵It could be the case in Italian, however, that the issue of automaticity is interacting with the issue of immediacy. That is, when the probe appears for up to 1500 ms and the task is a go/no-go task, the combination of both could lead to context and dominance influencing access.

⁶In addition, the point of lexical access in words will vary—especially in longer syllable words, the word may be accessed before the final syllables have been heard. This issue is critical because the question is whether all meanings are retrieved at the point of access. If the word has already been accessed (at, say, the second syllable), but the visual target doesn't appear until the end of the fourth syllable, 200–250 ms could have already passed by.

