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The Effect of Visual Target Presentation Times on Lexical Ambiguity Resolution*

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Although lexical ambiguity resolution has been examined extensively in the sentence processing literature, questions still remain as to why some cross-modal studies found that context influenced lexical access (i.e., Onifer & Swinney 1981), while others did not (i.e., Tabossi & Zardon 1993). In this study, the length of presentation time of the visual target at the ambiguity is manipulated (300ms, 750ms, and 1500ms) in three different cross-modal experiments in Mandarin Chinese when the auditory sentential context is biased toward the primary meaning of a lexical ambiguity. Results show that both the primary and secondary meanings are activated when the target is presented for 300ms and 750ms, but that only the primary meaning is activated when the visual target is presented for 1500ms. These findings suggest that once visual presentation times extend to one and a half seconds, context aids in selection of the multiple meanings that have been accessed prior to that point.

Key words: lexical ambiguity resolution, modularity hypothesis, cross-modal sentence processing, interaction hypothesis

Any theory of lexical ambiguity resolution must account for people's ability to comprehend the contextually appropriate meaning of an ambiguous word in ongoing, natural sounding speech. More precisely, the theory must specify how an ambiguous word is accessed and then integrated into ongoing sentential comprehension. In order to investigate this question, it is crucial that the focus be on on-line, as opposed to off-line, experimental tasks. Nicol et al. (in press), Swinney, Prather & Love (2000), and Ahrens (1998, 2001, 2002), among others, have emphasized the necessity of using tasks that

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match task time and task sensitivity to ongoing comprehension (i.e., on-line tasks) in order to look at moment-by-moment sentential processes. This paper argues that one critical timing issue has been overlooked with regard to cross-modal priming experiments for lexical ambiguity resolution, namely, the length of the visual target presentation.

There are two major hypotheses that attempt to explain the phenomena found in lexical ambiguity resolution, the **modularity hypothesis** and the **interactive hypothesis**. According to the modularity hypothesis, all meanings of an ambiguity are accessed regardless of the preceding sentential context (Fodor 1983, Forster 1979). This hypothesis is a general theory of cognitive processing which postulates that processing in any given module of the language processor (i.e., the lexical-level module) occurs independently of processing in any other module (i.e., in the discourse-level module) when language is being processed at natural speeds and under natural discourse conditions.

Two different versions of the modularity hypothesis can be distinguished depending on whether or not frequency is taken into account. According to the **multiple access** account, all meanings are accessed immediately and automatically (Conrad 1974, Kintsch & Mross 1985, Lucas 1987, Onifer & Swinney 1981, Seidenberg, Tanenhaus, Leiman & Bienkowski 1982, Swinney 1979, Tanenhaus, Leiman & Seidenberg 1979, Till, Mross & Kintsch 1988). However, as soon as 1500ms following the offset of the ambiguity, lexical selection occurs (Onifer & Swinney 1981, Swinney 1979, Swinney & Love 1996, Tanenhaus, Leiman & Seidenberg 1979). In addition, if the stimulus onset asynchrony (SOA, or time from the presentation of a prime word to the presentation of the target word) is varied, then shorter SOAs will allow access of all meanings, while longer SOAs allow access of contextually appropriate meanings (Seidenberg et al. 1982). This is not considered evidence against the modularity hypothesis since the late SOA presentation goes past the time point of immediate and automatic access and into the time-frame where context can choose from the meanings that have already been accessed.

The **ordered access** account is similar to the multiple access account in postulating a lack of influence of the preceding sentential context. Instead the lexical meanings are retrieved based on frequency rankings, with more frequent meanings being accessed faster. Both these accounts are known as context-independent accounts, because access is postulated to occur independently of the preceding context.

The modularity hypothesis has been challenged by data that shows that contextually appropriate meanings are facilitated relative to their control conditions, while inappropriate meanings are not (Li 1998, Li & Yip 1996, 1998, Lucas 1999, Simpson 1981, Tabossi 1988, Tabossi, Columbo & Job 1987, Tabossi & Zardon 1993; for an overview see Simpson 1994). These data support the interactive hypothesis, which is another general theory of cognitive processing that has also been extensively tested in terms of resolution of ambiguous words in contextually-biasing contexts

(McClelland 1987, McClelland & Rumelhart 1981, Marslen-Wilson & Tyler 1980, Marslen-Wilson & Welsh 1978). The strongest version of this hypothesis says that only the secondary meaning is primed when the contextual bias supports that meaning of the ambiguity. Tabossi & Zardon (1993) have noted that their data on lexical ambiguity resolution in Italian does not necessarily support the strongest version of the interactive hypothesis, since both the primary and secondary meanings were activated when the sentential bias was toward the secondary meaning of an ambiguity. However, they did find that only the primary meaning was activated when the sentential bias was toward the primary meaning. This finding indicates the inappropriate meaning was also activated only when its frequency of meaning was high. Tabossi & Zardon (1993) refer to this as a frequency and context effect; that is, both context and meaning frequency influence lexical ambiguity resolution. In an earlier paper, Duffy et al. (1988) suggest a similar idea. Their model, known as the reordered access model, has received considerable support in eye movement literature (for arguments supporting context effects in on-line reading studies see Martin et al. 1999, Vu et al. 2000, Vu, Kellas & Paul 1998; for a differing point of view see Binder & Rayner 1999, Binder 2003). However, there are also cross-modal lexical naming tasks in Cantonese, which present data showing that only the contextually appropriate meaning is available no matter whether the contextual bias is toward the primary or secondary meaning (Li 1998, Li & Yip 1996, 1998).

These conflicting results make it difficult to figure out which account of lexical ambiguity resolution is the most plausible. However, these previous experiments have differed along several different parameters. Variations involve the type of language being studied (Italian, Cantonese, Mandarin, or English), the modality of presentation (visual or auditory), the type of task used (lexical decision, naming, go/no-go task, gating), the presentation point of the visual target (onset/offset/post-onset), the position of the ambiguity in the sentence (sentence-medial or sentence-final), and the length of presentation of the visual target. Researchers have pointed out that in order to evaluate the conflicting claims surrounding lexical ambiguity resolution, every effort must be made to allow for immediate and automatic access to occur (see, for example, Ahrens 1998, 2001, 2002, Swinney 1979, Swinney, Prather & Love 2000, Nicol et al., in press). To this end, it has been suggested that the modality of the sentential presentation be auditory and that the task be a cross-modal priming task (Nicol et al., in press). In addition, the presentation point should occur no later than the offset of the ambiguity (McClelland 1987, Onifer & Swinney 1981, Simpson 1994), and the position of the ambiguity should be sentence-medial (Balogh et al. 1998).

It is still an open question as to whether the language or the length of the visual target presentation may have an effect on whether context can influence lexical access. Nevertheless, the conflicting findings between Mandarin, where evidence for the

modularity hypothesis was found (Ahrens 1998, 2001, 2002), and Cantonese, where evidence to support the interactive hypothesis was found (Li 1998, Li & Yip 1996, 1998), beg the question as to why these typologically similar languages would differ in their lexical ambiguity resolution methods. One possible explanation is that it is not the language that is driving the difference in findings; it is instead the length of the presentation time of the visual target, since Li & Yip (1996, 1998) had visual target presentation times of 1500ms or greater, while Ahrens (1998, 2001, 2002) found multiple access occurred for target presentation times of 300ms. Moreover, other data that found for selective access also had visual target presentation times of 1500ms (Tabossi & Zardon 1993), while data that supported a modular access account all had visual target presentation times of 1000ms or less (Ahrens 1998, 2001, 2002, Onifer & Swinney 1981, Swinney 1979, Swinney & Love 1996, Tanenhaus et al. 1979).

Thus, the possibility exists in both Italian and Cantonese that the length of visual presentation time of the target word was so long (i.e., 1500ms or greater) that lexical access had already taken place by the time the subjects made a decision. That is to say, the long visual presentation time did not give adequate opportunity for immediate and automatic access (two prerequisites for modularity) to occur. An alternate possibility is that the findings for Mandarin were specific to the fact that the experimental stimuli were all biased toward the secondary meaning of the ambiguity, and that when the bias is toward the primary meaning of the ambiguity, only selective access occurs. This would be evidence for the Language-driven Hypothesis (Ahrens 1998) which postulates that the context-prominence of a language will influence whether or not lexical access may occur immediately and automatically.

The goal of the following three experiments is to investigate whether the presentation length of the visual target influences lexical access. In the three experiments discussed below, the sentences are biased toward the primary meaning of the nominal ambiguity to see if there is facilitation for both primary and secondary meanings with a visual target presentation time of 300ms, 750ms, and 1500ms respectively. It is proposed that the strongest evidence for either the modularity hypothesis or interactive hypothesis should ideally come from experiments where lexical access is as immediate and automatic as possible given human processing constraints. Thus, it is hypothesized, based on the literature, that the visual target presentation times that are less than 1000ms will allow for multiple access of ambiguous meanings, but that visual target presentation times that are 1500ms (or greater) will show priming effects for only the contextually appropriate meaning. However, the interactive hypothesis predicts that even at shorter visual target presentation times, lexical access should still be influenced by context. In short, there is no doubt that context plays a role in lexical ambiguity resolution; the issue at stake is precisely when context plays a role—before lexical access or after?

1. Experiment 1

In Experiment 1, the visual target in the cross-modal lexical decision task is presented for 300ms. The modularity hypothesis predicts that both meanings will be accessed regardless of the fact that the sentential context is biased toward the primary meaning, while the interactive hypothesis predicts that only the primary meaning of the ambiguity will be accessed.

1.1 Method

1.1.1 Participants

Seventy-four participants (mean age = 19.2 years, SD = 1.3 years) took part in the on-line cross-modal lexical decision task. These participants were all undergraduate students of National Taiwan University, lived in Taiwan since birth, and were native speakers of Mandarin Chinese. In Taiwan, there is usually another language spoken in the home in addition to Mandarin, such as Taiwanese, Hakka, or an Austronesian language. In order to keep the participant pool as homogenous as possible in terms of language background, all participants used in the following experiments were exposed not only to Mandarin, but also to Taiwanese in the home before the age of seven. In addition, they had no exposure to other dialects or languages before seven. Participants were also screened for any brain injury, learning disability, visual impairment, or auditory impairment. All participants were paid NT$100 (equivalent to US$3.60) for their participation, which took approximately one-half hour. None of the participants participated in any of the pretests for the stimuli.

1.1.2 Stimuli

A script was designed with a total of 42 sentences, 16 experimental sentences and 26 filler sentences. The filler sentences were of approximately the same complexity as the experimental ones in order to deter participants from creating any sort of strategy while the experiment was progressing. Four lists were constructed so that no one visual probe was linked to a condition more than once to avoid repetition effects. There were 21 non-words and 21 words in each list. The 64 visual probes were matched and rotated through each of the four lists in a Latin Square Design.

The determination of the meanings of the ambiguities and the creation of the experimental sentences are described below.

1.1.3 Pretest for Ambiguity Bias

Thirty undergraduates in National Chung Cheng University (mean age = 19.5, SD

= 1.2 years) were presented with ninety disyllabic words (52 nouns, 38 verbs), which had at least two meanings based on the judgments of two linguistically trained native Mandarin speakers. These participants did not participate in any other pre-tests or on-line studies. The words were presented from a pre-recorded audiotape, since words often have different auditory and visual biases. For each word, participants were asked to provide the first meaning that came to their mind, and then to provide any additional meaning or meanings that came to mind in their respective orders. Tallies of the numbers of the first and second choices for each meaning of the words were carried out.

For the present study, 16 nouns were chosen which had a preference for the primary interpretation (i.e., the primary meaning was given as the first-choice meaning for speakers over 75% of the time); and in addition, the secondary meaning was given as the second-choice meaning for speakers over 60% of the time. The verbs were used in a separate study (Ahrens 2001).

1.1.4 Pretest—Visual Probes

Probes for the Primary and Secondary meanings of the ambiguity were chosen by using one of the three most frequently provided associates from the previous pretest above. The following restriction applied: 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 bases of frequency, length, and form class were included with the associated words in an isolated lexical decision task. The purpose of the isolated lexical decision task is to determine the lexical decision times of the words a priori to running the cross-modal experiment. A separate group of twenty-two participants (mean age = 19.8 years, SD = 1.0 years) from National Taiwan University participated in this experiment. After screening for errors (higher than 10% button-press errors or no responses) and language exposure, data from twenty participants were analyzed. The average reaction time for each word in the list was calculated over all participants. After the average RT for each word was calculated, a "matched" control word was chosen for each "related" associate for each meaning of the ambiguity (i.e., Primary and Secondary). Overall, the mean reaction times for the Primary experimental and control conditions were 581ms and for the Secondary experimental and control conditions were 577ms. In addition, the experimental and control conditions were matched across individual items for syllable length for the primary meaning (mean = 2.05 syllables, SD = .2 syllables) and for the secondary meaning (mean = 2.1 syllables, SD = .4 syllables). Lists were also matched for frequency so that the experimental and control conditions for the primary and secondary meanings did not significantly differ from one another: primary control words = 7464, primary experimental words = 7820, $t(30)=.117$, $p>.05$; secondary control words = 8271, secondary experimental words =

9260, t(30)=.352, p>.05. In addition, working against the hypothesis under investigation, the means of the words in the control conditions were more frequent than the means of those in the experimental condition.

1.1.5 Creation and Pretest of Sentential Materials

Experimental sentences were created according to the following criteria. First, the context of each sentence was strongly biased toward the primary, dominant meaning of the ambiguous word tested. A separate group of twenty-one students at National Taiwan University (mean age = 21.3 years, SD = .7 years) was given an untimed off-line task, which consisted of reading the actual experimental sentences up to the point just before the ambiguity. For example, they were given the sentence found in Table 1 up to the character *le*, which is an aspect marker that follows a verb. A blank underline followed immediately after the character for *le*. They were then asked to complete the sentences. Following Tabossi et al.'s (1987) criterion for the existence of a strong bias toward one meaning of the ambiguous word, an item was accepted for use in the main experiment only if the completions supplied by at least 75% of all 21 participants exhibited the contextually favored interpretation.

A sample experimental sentence for the ambiguous word *fànwǎn* (lit. 'rice-bowl') is given in Table 1. The experimental and control visual targets for primary and secondary meanings of *fànwǎn* are given in Table 2.[1] (To "break a rice-bowl" can have an idiomatic meaning, to 'lose one's job'.)

Table 1: Sample experimental sentence with the ambiguous word *fànwǎn*

Zhōngguó	*Xīnnián*	*yǒu*	*xǔduō*	*tèbié*	*ér*	*yǒuqù*	*-de*	
China	New Year	have	many	special	and	interesting	MOD	
xísú,	*bǐfāng-shuō,*	*rúguǒ*	*zài*	*guònián*	*qíjiān*	*bùxiǎoxīn*	*zá*	*-le*
custom,	for example,	if	in	New Year	period	careless	break	ASP
<u>fànwǎn</u>	*huò*	*jìngzi*	*zhè*	*-zhǒng*	*yìsuìwù*		*-dehuà*,	
rice bowl	or	mirror	this	kind	easy-break thing		(if),	
jiù	*yào*	*gǎnjǐn*	*shuō*	*"Suìsuì Píngān"*	*yǐ*	*qiú*	*jílì.*	
then	must	boldly	say	"every year safe"	so	beg	lucky	

"There are many special and interesting customs for Chinese New Year. For example, if you carelessly break something fragile during the New Year season, such as a rice bowl or a mirror, you must say *Suìsuì Píngān*, so as to ask for luck."

[1] A copy of all the experimental materials is available from the author upon request.

Table 2: The experimental and control visual targets for primary and secondary meanings of the ambiguous word: *fànwǎn*

	Experimental visual target	Control visual target
Primary meaning	*Róngqì* (container)	*Zhènmín* (town people)
Secondary meaning	*Zhíyè* (profession)	*Tīngzhòng* (audience)

Overall, the number of characters before the ambiguous word ranged from 27 to 39, and the average was 33. The number of characters after the ambiguous word ranged from 23 to 35, and the average was 27.

1.1.6 Apparatus

The 42 experimental and filler 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 offset of the ambiguous word was measured using the same program. This information was then entered into a master list that associated the time of presentation along with each respective sentence and visual probes. At the time of the offset of the ambiguous word, 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 measurements were made to the nearest millisecond. The sentences occurred in random order, and there was a four second delay between sentences.

1.1.7 Procedure

Participants sat in front of a computer monitor in a quiet room and were told that they had two tasks. The first task was to listen to and understand the sentences that they heard over headphones. They were told that they would be tested on these sentences at the end of the experiment. The second task was to watch the computer screen and when they saw Chinese characters appear on the screen, they had to decide if the characters made up a word or not. They made this binary decision with a two-button button box specifically designed for this purpose. They were told to press the right hand button ("word" button) if they thought it was a word, and to press the left hand button ("non-word" button) if they thought it was not a word. They were asked to keep their fingers on the buttons at all times and to respond as fast and accurately as possible. The auditory presentation of the sentences continued on without interruption even when the visual probe appeared and when participants were making their decision. The computer

screen was covered with a piece of dark gray cardboard with a rectangular cut out of its center so that participants' attention would be on the center of the computer screen.

At the end of the experiment, the participants were given 10 sentences printed on a sheet of paper and asked to mark which sentences they had just heard. Five sentences were exactly the same as they had heard previously, and five sentences had half of their content different. This memory test was done to ensure that the participants were paying attention to the auditorily presented sentences and not just making lexical decisions without attending to the content of the sentences. In the instructions, it was emphasized that participant would have two tasks: to listen to the sentences and to make a lexical decision when a word appeared on the screen.

1.2 Results and discussion

After screening for participants who had more than 15% errors overall on the lexical decision task (4 Ss) or who had three or more items wrong on the ten-item memory test (29 Ss) or who did not complete the task due to technical difficulties (1 Ss), there were 40 participants with reliable data, 10 participants for each list. The outliers from the data were trimmed by excluding outliers above and below two standard deviations from the conditional means across all subjects of probe type and ambiguity meaning combinations, which resulted in excluding 5.2% of the data.

Table 3 below presents the mean reaction times of correct responses in each condition.

Table 3: Mean reaction times (in milliseconds) for related and control probes for both primary and secondary meanings of the ambiguity when the visual target is presented for 300ms

Meaning of the ambiguity	Visual Target 300ms	
	Related	Control
Primary	675*	698
Secondary	689*	709

*p<.05

When the visual target is presented for 300ms, the visual target related to the primary meaning of the ambiguity (i.e., the appropriate meaning) is 23 milliseconds faster than its control word (cf. 675ms with 698ms). Moreover, the visual target related to the secondary meaning of the ambiguity (i.e., the inappropriate meaning) is 20 milliseconds faster than its control word (cf. 689ms with 709ms). A 3-way ANOVA was run on individual participants data employing Lists (4) as a between-participants factor (materials counterbalancing factors) and Ambiguity Meaning (Primary and Secondary)

and Probe Type (Related and Control) as within-participants factors. An overall significant main effect of Probe Type was found for participants ($F_1(1,36)=6.19$, MSE= 3161, $p<.05$) and a main effect for items ($F_2(1,48)=4.09$, MSE=7915, $p<.05$). No interaction effect was found between the Probe Type and Ambiguity Meaning for either participants ($F_1(1,36)=.037$, MSE=2996 $p=.849$) or items ($F_2(1,48)=1.418$, MSE=7915, $p=.240$). There was no main effect of list for participants ($F(3,36)=.768$, MSE=30243, $p=.530$). There was a simple main effect (one-tailed) within the primary meaning (Related vs. Control) for participants ($t(72)=1.92$, MSE=3079, $p<.05$) and items ($t(48)=2.27$, MSE=7915, $p<.05$).[2] There was also a marginal simple main effect (one-tailed) within the secondary meaning for Participants ($t(72)=1.65$, MSE=3079, $p=.052$), but not for items ($t(48)=.589$, MSE=7915, $p=.28$).

The data demonstrate that both the primary and secondary meanings were activated when the sentential bias was toward the primary meaning and visual target was presented for 300ms. The fact that both the primary and secondary meanings were facilitated by about 20ms, and the fact that the effect sizes were relatively small indicate that there was no facilitation advantage for the primary meaning over the secondary meaning. Thus, these data support the multiple access account within the modularity hypothesis, since the interactive account would predict that only the contextually appropriate meaning would be activated, instead of both meanings, as was found here.

2. Experiment 2

In Experiment 2, the visual target in the cross-modal lexical decision task is presented for 750ms. The prediction is that this visual target presentation time will also allow for multiple access, since all experiments that found for multiple access had a visual target presentation time of one second or less (i.e., Ahrens 1998, 2001, 2002, Onifer & Swinney 1981, Swinney 1979, Swinney & Love 1996, Tanenhaus et al. 1979).

2.1 Method

2.1.1 Participants

A separate group of sixty-two undergraduates (mean age = 19.0 years, SD = 1.0 years) from National Taiwan University participated in this on-line cross-modal lexical

[2] The MSE for participants as the random factor was pooled from the error terms associated with the Probe Type and Probe Type by Ambiguity Meaning interaction; in the item analysis the Probe Type and interaction have the same error term, which is then used in testing the simple main effects; both procedures are carried out following Kirk's (1982) discussion of rules for choice of error terms for simple main effects.

decision task. None of the students had participated in any of the pretests, nor had they participated in Experiment 1.

2.1.2 Stimuli and procedure

Experiment 2 used the same stimuli as Experiment 1. The only difference in procedure was that the visual target stimulus was presented for 750 ms (as compared with 300ms as in Experiment 1 and 1500ms in Experiment 3).

2.2 Results and discussion

Participants were screened for having more than 15% errors overall on the lexical decision task (4 Ss) or who had three or more items wrong on the ten-item memory test (15 Ss). In addition, after the experiment was run, it was found that three participants had been exposed to a language other than Mandarin or Taiwanese before the age of 7. These participants were also excluded from the data analysis. After these screenings occurred, there were 40 participants with reliable data, 10 participants for each list. The outliers from the data were trimmed by excluding outliers above and below two standard deviations from the conditional means across all subjects of probe type and ambiguity meaning combinations, which resulted in excluding 5.6% of the data.

Table 4 below presents the mean reaction times of correct responses in each condition.

Table 4: Mean reaction times (in milliseconds) for related and control probes for both primary and secondary meanings of the ambiguity when the visual target is presented for 750ms

Meaning of the ambiguity	Visual Target 750ms	
	Related	Control
Primary	670*	696
Secondary	682*	701

*p<.05

When the visual target is presented for 750ms, the visual target related to the primary meaning of the ambiguity (i.e., the appropriate meaning) is 26 milliseconds faster than its control word (cf. 670ms with 696ms). In addition, the visual target related to the secondary meaning of the ambiguity (i.e., the inappropriate meaning) is 19 milliseconds faster than its control word (cf. 682ms with 701ms).

A 3-way ANOVA was run on individual participants data employing Lists (4) as a between-participants factor (materials counterbalancing factors) and Ambiguity Meaning

(Primary and Secondary) and Probe Type (Related and Control) as within-participants factors. An overall significant main effect of Probe Type was found for participants (F_1 (1,36)=12.74, MSE=1631, p<.001) but not for items (F_2(1,48)=1.90, MSE=10314, p =.177). No interaction effect was found between the Probe Type and Ambiguity Meaning for either participants (F_1(1,36)=.166, MSE=2781, p=.686) or items (F_2(1,48) =.252, MSE=10314, p=.618). There was also no main effect of list for participants (F(3,36)=1.019, MSE=37823, p=.396). There was a simple main effect (one-tailed) within the primary meaning (Related vs. Control) for participants (t(72)=2.494, MSE= 2206, p<.001) and a marginal main effect for items (t(48)=1.329, MSE=10314, p=.091). There was a main effect (one-tailed) within the secondary meaning for participants (t(72) =1.846, MSE=2206, p<.05,) but not for items (t(48)=.619, MSE=10314, p=.369).

The data demonstrate that both the primary and secondary meanings were activated when the sentential bias was toward the primary meaning and visual target was presented for 750ms. The fact that both the primary and secondary meanings were facilitated by about 20ms, and the fact that the effect sizes were all relatively small again all indicate that there was no facilitation advantage for the primary meaning over the secondary meaning. Thus, these data again support the multiple access account within the modularity hypothesis and suggest that this bottom up information retrieval still has not been affected by top down constraints at the time that the lexical decision is made. It is hypothesized, however, that a longer visual target presentation time of 1500ms will demonstrate context effects.

3. Experiment 3

In Experiment 3, the visual target in the cross-modal lexical decision task is presented for 1500ms. This length of presentation is postulated to be outside the timing necessary for the immediate and automatic processing postulated within the modularity hypothesis, and as such, only the contextually appropriate (i.e., primary) meaning should be activated.

3.1 Method

3.1.1 Participants

Sixty-four participants from National Taiwan University (mean age = 19.6 years, SD = 1.3 years) participated in this on-line cross-modal lexical decision task. None of the participants participated in any of the pretests, nor had they participated in Experiment 1 or 2.

3.1.2 Stimuli and procedure

Experiment 3 used the same stimuli as Experiments 1 and 2. In addition, the only difference in procedure was that the visual target stimulus was presented for 1500ms (instead of 300ms as in Experiment 1).

3.2 Results and discussion

After screening for participants who had more than 15% errors overall on the lexical decision task (3 Ss) or who had three or more items wrong on the ten-item memory test (18 Ss) or who did not complete the task due to technical difficulties (3 Ss), there were 40 participants with reliable data, 10 participants for each list. The outliers from the data were trimmed by excluding outliers above and below two standard deviations from the conditional means across all subjects of probe type and ambiguity meaning combinations, which resulted in excluding 4.7% of the data.

Table 5 below presents the mean reaction times of correct responses in each condition.

Table 5: Mean reaction times (in milliseconds) for related and control probes for both primary and secondary meanings of the ambiguity when the visual target is presented for 1500ms

Meaning of the ambiguity	Visual Target 1500ms	
	Related	Control
Primary	754*	787
Secondary	757	764

*p<.05

When the visual target is presented for 1500ms, the visual target related to the primary meaning of the ambiguity (i.e., the appropriate meaning) is 33 milliseconds faster than its control word (cf. 754ms with 787ms). In addition, the visual target related to the secondary meaning of the ambiguity (i.e., the inappropriate meaning) is only 7 milliseconds faster than its control word (cf. 757ms with 764ms). A 3-way ANOVA was run on individual participants data employing Lists (4) as a between-participants factor (materials counterbalancing factors) and Ambiguity Meaning (Primary and Secondary) and Probe Type (Related and Control) as within-participants factors. An overall significant main effect of Probe Type was not found for participants ($F_1(1,36)=1.82$, MSE=8803, p=.2) nor for items ($F_2(1,48)=.935$, MSE=13258, p=.4). No interaction effect was found between the Probe Type and Ambiguity Meaning for either participants

($F_1(1,36)=1.550$, MSE=4566, p=.221) or items ($F_2(1,48)=.082$, MSE=13258, p=.776). There was also no main effect of list for participants (F(3,36)=.688, MSE=78986, p =.565). In order to investigate the hypothesis in question, further analyses were run on the Ambiguity Meaning condition. There was a simple main effect (one-tailed) within the primary meaning (Related vs. Control) for participants (t(72)=1.82, MSE=6685, p<.05) but not for items (t(48)=.765, MSE=13258, p=.224). There was no main effect (one-tailed) within the secondary meaning for Participants (t(72)=.366, MSE=6685, p =.358) nor for items (t(48)=.361, MSE=13258, p=.360).

The data demonstrate that only the primary meaning was activated when the sentential bias was toward the primary meaning and visual target was presented for 1500ms. This suggests, when compared with the previous two experiments, that a presentation time of 1500ms does not allow immediate and automatic access to occur.

4. General discussion

The results of the three experiments presented here indicate that both meanings were accessed when the visual target was presented for less than one second (i.e., 300ms or 750ms), but that only the contextually appropriate meaning was accessed when the visual target was presented for 1500ms. A plausible interpretation of this data is that both meanings of an ambiguity are automatically accessed (even in a biasing context toward the primary meaning) and that the contextually appropriate meaning is quickly selected.

The present results explain why previous experiments differed in their findings for lexical access in on-going speech comprehension. In particular, Ahrens (1998, 2001, 2002) noted that experiments that reported evidence for multiple access in cross-modal tasks all had a visual target presentation time of 1000ms or less, while experiments that found evidence for selective access all had a visual target presentation time of 1500ms or more. Our study also supports the view that previous work that argued against exhaustive access did not test the possibility of contextual influence under the appropriate conditions for modularity, because the visual target presentation was too long for immediate and automatic access to occur. Two reasons could underlie this phenomenon. One is that the increased visual target time leads to an increase in response time so that that response is made after lexical access has already occurred, and context then selects the appropriate meaning. Another possibility is that the fact that the visual target stays on-screen until the decision is made the majority of the time (which happens in the 1500ms condition) either impedes or fails to activate the meanings of the word immediately and automatically as is required for modularity. One way to test these possibilities is to run a within-subject decision for the presentation rates to see if similar findings as found here still hold.

However, in order to do so, one would need three times as many experimental stimuli and an experimental program that allows one to modify the stimulus presentation time independently.

Indeed, given the findings presented in this paper, it becomes incumbent upon future researchers to ascertain that they are using tasks and timing procedures that are conducive to immediate and automatic processing. Tasks, such as the gating task used in Li & Yip (1998), or the go/no-go task used in Tabossi et al. (1987) are also not conducive to immediate and automatic processing and may show results that seem to support an interactive hypothesis. Instead what they may reflect are issues relevant only to the particular task (i.e., guessing in the gating task, or inhibition in the go/no-go task) or issues relevant to the timing (i.e., lexical access has already occurred).

Another related issue that may be relevant to the question of immediate and automatic access has to do with determining the point in time where word-recognition occurs. In an ideal situation, the ambiguous word would be presented not at the offset of the ambiguous word, but instead, exactly at the point where word recognition occurs. Obviously, this additional factor would involve a series of gating pre-tests in order to determine where word recognition occurs for each lexical item (Moss & Marslen-Wilson 1993), and may particularly important in a polysyllabic language such as Italian.

The memory span of the participants is an additional issue that may affect the results found in ambiguity resolution experiments. For example, in the three experiments presented here, approximately one-third of the participants failed the memory task after the experiment and had to be replaced. The memory task was designed to make sure that the participants listened carefully to the auditorily presented sentences in addition to making the lexical word choice decision to the visual target. The memory task was chosen over a multiple choice comprehension task after particular sentences so that the stimuli could be presented randomly. However, it might be the case that this exclusion of participants resulted in analyzing data from participants with a high verbal working memory span, which might not extend to the general population at large. Miyake, Just & Carpenter (1994), for example, inferred from their data that low-span readers held the dominant meaning of an ambiguity in memory more strongly than high-span readers, who were able to hold both meanings of an ambiguity in memory. In addition, Kazmerski, Blasko & Dessalegn (2003) found that participants with a high verbal working memory had different N400 amplitudes when compared with low verbal working memory participants in a literal truth task for metaphors. The authors postulate that one reason for this difference may be that the less skilled readers need to use their resources as efficiently as possible, and so they do not let metaphorical interpretation interrupt their completion of the overt tasks at hand—reading and truth judgments. Better readers, however, can do all three tasks at once.

A related point is discussed in Swaab, Brown & Hagoort (2003), who note that college-age students accessed both primary and subordinate meanings in an auditory ERP study, regardless of contextual bias. This finding supports the results presented herein, but contrasts with a previous study (Swaab, Brown & Hagoort 1998), which found that elderly controls did not activate contextually inappropriate (secondary) meanings under contextual conditions that biased to the primary meaning. The authors argue that this indicates that older adults use context more effectively. Another way of looking at the question, though, is to ask if the elderly participants' verbal working memory span is high or low. If it is low, then perhaps they, like the participants in the Kazmerski et al. (2003) study, could only do so much with limited resources. Thus, another area for future research is to explore the possible differences between subjects with high and low verbal working memory to see if they have different ways of coping with lexical ambiguity resolution.

A crucial function of language is to convey meaning and intent in an unambiguous way. In fact, although languages are filled with ambiguous lexical items, these same items are used most of the time unambiguously within a particular sentential context. Thus, human beings know (from self-introspection as well as experimentation) that selection of lexical meaning does take place. Moreover, it often takes place so quickly that people are not consciously aware that they have even processed an ambiguity. The experiments discussed here present evidence that the processor first runs a bottom-up analysis which accesses all meanings of an ambiguity and then, once these meanings have been accessed, the top-down processor quickly chooses the contextually appropriate one. These findings fit in well with Nicol et al.'s (in press) proposal that cross-modal lexical priming tasks, when used in its standard, fluent form, is an appropriate method to explore lexical activation. This study here adds to their work by proposing that in addition to their guidelines concerning the appropriate use of the CMLP task (including continuous presentation, no metalinguistic judgements, uninterrupted processing, etc.), timing issues such as the length of visual target presentation times are also crucial to ensuring that the modularity of the processor has not been violated. Thus, the findings presented here argue that a modular process occurs when a lexical ambiguity is encountered in on-going speech comprehension, and propose that previous experiments that found for interactive access all, in some way, violated the constraints required for modular processing to occur.

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在詞彙歧義理解上視覺目標的呈現時間效應

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雖然文獻上有關詞彙歧義理解的研究很多，不過仍有一些問題尚待解決，例如爲什麼在跨模式實驗中，有些實驗顯示語境會影響詞彙觸接 (i.e. Onifer and Swinney 1981) 但是有些實驗卻沒有發現語境效應 (i.e. Tabossi and Zardon 1993)。在這個研究中，我們一共執行了三個跨模式實驗，我們視覺呈現了具有歧義的中文目標，並操弄了呈現時間的長度 (300ms, 750ms, and 1500ms)，同時我們聽覺呈現了句子式語境，不過語境提示了歧義詞彙的主要語意。結果顯示當目標 300 或 750 毫秒視覺呈現時，主要及次要語意兩者都會激發。但是當目標在 1500 毫秒視覺呈現時，只有主要語意才會激發。這個研究建議：雖然多重語意在一秒半前都會被激發，不過當視覺目標的呈現時間延長至一秒半時，語境才可以幫助多重語意的選擇。

關鍵詞：詞彙歧義理解，模組假設，跨模式句子處理，交互假設