Meaning inhibition and sentence processing in Chinese: Evidence from negative priming

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ABSTRACT

The present study was designed to further examine the inhibitory processes of spoken word recognition of Chinese homophones during sentence processing. In this study, we employed the negative priming paradigm in a cross-modal naming experiment. In the experiment, all the native Cantonese listeners were asked to name aloud a visual probe as quick and accurate as they could after hearing a sentence, which ended with a homophone. Results suggested that preceding sentence context has an early effect on selecting the appropriate meaning among all the other alternative meanings of the homophone. Furthermore, negative priming effects were observed that the contextually inappropriate meanings of the homophone were inhibited rapidly during sentence processing.

1. INTRODUCTION

It is a long-studied psycholinguistic problem to look into the dynamics of interaction of context effects and spoken word recognition processes [1-10]. The main focus is on the cognitive processes of how and when the context effects on different stages of lexical access. Empirical answers for these core questions lead to two major contrasting hypotheses. The first one is the exhaustive access hypothesis, which argues that all meanings of an ambiguous word will be accessed momentarily following the occurrence of the ambiguous word, and the sentence context can only help to select the appropriate meaning at a late post-access stage. This hypothesis assumes a modular approach in language processing in which all the bottom-up, non-lexical, contextual information cannot penetrate lexical access [11]. The second one is the context-dependency hypothesis, which argues that only the contextually appropriate meaning of the ambiguous word will be accessed early on if the preceding sentence context provides a strong bias to the appropriate meaning due to its enhanced activation. This hypothesis assumes an interactive approach in language processing in which information can flow both bottom-up and top-down simultaneously and that lexical access and sentence context can mutually influence each other at an early stage [12].

Many experimental psycholinguistics studies examine the above hypotheses have been extensively conducted in different languages (Chinese, Dutch, English, and Italian) during the last three decades despite of the different patterns of results were found. Only a very few studies were systematically examined the inhibitory processes of the different alternative meanings of the ambiguous word thereafter [13]. Previous studies found that the contextually inappropriate meanings of the ambiguous word would be suppressed rapidly, within 200 ms, following the occurrence of the ambiguous word so as to sustain the normal sentence processing [14]. Other experimental study also demonstrated that the inhibitory processes of those unselected or those contextually inappropriate meanings would still be sustained for a certain period of time until our language processor selected the contextually appropriate meaning, might be longer than one second [15]. The present study attempts to further investigate this rarely addressed question by using Cantonese Chinese as a testing case. Cantonese Chinese is a language that differs significantly from most other languages (e.g., in its use of lexical tones, its morphemic monosyllabicity) and lexical ambiguity is pervasive in Chinese (in terms of its extensive homophony). Therefore, it offers many unique and interesting psycholinguistic properties in its phonological, lexical, and syntactic structures [16] to crucially investigate the issue.

According to the Modern Chinese Dictionary [17], about 80% of the monosyllables (with tonal differentiation) in Chinese are ambiguous between two different meanings, and about 55% have five or more alternative meanings. For example, a single Cantonese syllable si1 has up to 14 meanings (e.g., teacher, lion, silk, corpse, poem, private, think, etc.) [18]. Then, upon hearing the syllable si1 in a highly semantically constraint sentence, do native Cantonese listeners activate only the most contextually appropriate meaning out of the total 14 meanings and inhibit the other contextually inappropriate meanings of the single syllable simultaneously [19]? What would be the entire inhibitory process? Would there be any other lexical variables affected the inhibitory processes? How long the inhibition can be sustained? In the present study, we attempt to answer these aforementioned questions, by using the negative priming paradigm, in order to seek additional new evidence to unfold the complete picture to the time course along the cognitive processing of spoken word recognition.

2. EXPERIMENT

2.1. Method

Participants. Sixty-four native Cantonese speakers (26 male and 38 female, mean age =21.6) who reported no speech or hearing deficits participated in this experiment. All participants were students at the Open University of Hong Kong and the Hong Kong Institute of Education. They were paid HK$30 as a token of gratitude to take part in the experiment.

Materials and design. Thirty spoken Cantonese homophones were selected, each with at least two different meanings in the same tone (syllables with different tones are
not considered homophones in the present study). Each homophone was embedded in four different types of sentences, in a two (Dominance: dominant vs. subordinate) by two (Reiteration: reiterated vs. not reiterated) mixed design, they are: (1) With preceding sentence context biased to the dominant meaning of the ambiguous word and then reiterated the ambiguous word again at the end of the sentence in which the corresponding sentence context biased to the subordinate meaning of the ambiguous word (DR). (2) With preceding sentence context biased to the subordinate meaning of the ambiguous word first and then reiterated the ambiguous word again at the end of the sentence in which the corresponding sentence context biased to the dominant meaning of the ambiguous word (SR). (3) With preceding sentence context biased to the dominant meaning of the ambiguous word at the end of the sentence and without reiterated the ambiguous word in the middle position of the sentence (DN). (4) With preceding sentence context biased to the subordinate meaning of the ambiguous word at the end of the sentence and without reiterated the ambiguous word in the middle position of the sentence (SN). All the testing sentences will have two parts with a 500 ms pause in between, immediately after the first occurrence of the homophone.

Following from the construction of these materials, we set out the different predictions for the current experiment: (1) the response latencies to related visual probes of condition (DN) will be faster than (SN) and the response latencies to related visual probes of (SR) will be faster than (DR) due to a simple dominance effect. (2) the response latencies to related visual probes of condition (DN) will be faster than (SR), the response latencies to related visual probes of condition (SN) will be faster than (DR), and the response latencies to related visual probes of condition (DR; SR) will be slower than unrelated control due to the inhibitory effects of the inappropriate meanings of the ambiguous words at the first occurrence. The rationale is that by comparing the response latencies to related visual probes of conditions (SR) and (DN) or (DR; SR) and unrelated control, we can see that if the activation level of the inappropriate meaning of the ambiguous word (only the contextually appropriate meaning is accessed when hearing the ambiguous word at the first time in the middle of the sentence) will eventually decrease and sustain to the end of the entire sentence frame in which the ambiguous word is reiterated again at the end of the sentence; and hence the inhibition of the inappropriate meaning will arrive at a level that makes a slower response latencies than the time observed in DN condition, in which no inhibition to the inappropriate meaning of the ambiguous word has been occurred. This is a typical Negative Priming effect (NP); NP is a type of slow and error-prone response to a stimulus that is previously ignored [20]. If this is the case, it certainly confirms the inhibitory effects take place during the sentence processing and also these inhibitory effects can sustain to a certain period of time.

Following the procedure of relevant studies [21], a separate group of 20 native Cantonese speakers was asked to judge the degree of constraint of the sentence context on the homophone. They were given all the testing sentences with the preceding biasing context but without the homophone, and were asked to fill in the word. They were told to think of a Chinese word that would naturally complete the sentence. Their responses were scored on a 1-4 scale, based on the scale proposed by Marslen-Wilson and Welsh [22]: 1 was given for a word identical to the test word, 2 for a synonym, 3 for a related word, and 4 for an unrelated word. Responses were pooled across the 20 judges, and the mean rating was 1.8. This score was above the high constraint condition in Marslen-Wilson and Welsh’s study [22]. An effort was also made to have the sentence context of equal length, and the average length of the test sentences, including the homophones, was 26 words (ranging from 24 to 27 words). In addition, we have made an effort to eliminate any kind of intra-sentential priming from other individual words within the whole sentence frame when constructing the sentence context as much as possible.

Other than the sentence context, we carefully selected the appropriate visual probes as follows. First, all the visual probes were based on a semantic relatedness norm experiment from another separate group of one hundred native Cantonese speakers. In this simple experiment, the participants were asked to immediately think of three Chinese words that have the same or closely related meaning to each homophone, and the most frequent words they listed were used to be the related visual probe for each homophone. The set of unrelated visual probes used in the experiment was also carefully selected in this experiment. All the visual probes in each experimental condition were carefully matched with the same category of initial phonemes and individual frequency information.

Three main variables were manipulated in this experiment: (1) Dominance: The sentence context was either biased to the dominant meaning of the spoken homophone or to the subordinate meaning of the spoken homophone. The dominance information was empirically based [23]. (2) Reiteration: The homophones were either reiterated in the middle of the whole sentence or not. (3) Relatedness: The visual probes were either related to the dominant meaning of the spoken homophone or to the subordinate meaning, or unrelated.

An example *sil* (silk/poem) in the four different types of sentence context is given below. (* denotes the 500ms pause)

| DR | Sai3 lo5 lam5 ye5 lam5 do3 tau4 faat3 do1 hei2 saai3 *sil* * tai2 lai4 ku15 gam1 yat6 do1 gai2 lam4 jok3 do2 yat1 sau2 *sil*. Young brother is thinking very hard that his hair seems like gradually becoming silk*, I do not think that today he can finally compose a poem. |
| SR | Dong1 ga1 jai1 hai5 sue1 fong2 lui5 min6 yam4 gan2 sau2 *sil* * ma1 me4 jau6 hui3 joh2 sui6 fong2 do6 tong3 gan2 san1 maai5 di1 *sil*. When elder sister is, inside her studying room, reading aloud a poem*, mother at the same time, in her bedroom, is ironing her newly-bought silk. |
The six visual probes to *sil* in these sentences are: *saam1 “shirt”* (SR and DN), *man4 “prose”* (DR and SN), and *booi1 “cup”* and *lei4 “pear”* (unrelated control).

**Experimental Apparatus.** All the test sentences were read by a female native Cantonese speaker at a normal conversation speed and tape-recorded digitally in a SONY MD. All the spoken sentences were then transferred and digitized into a Macintosh PowerBook. A computer program called PsyScope [24] controlled the presentation of the materials in the experiment. A microphone, which was used to register listeners’ vocal responses and hence calculated the naming latencies, was connected to the notebook computer. A remote controlled SONY IC-recorder was used and controlled by the experimenter in another partition of the experimental room to check for accuracy.

**Procedure.** Each participant randomly received an equal number of sentences (fifteen) for each condition in the 2 (Dominance) x 2 (Reiterated) x 2 (Relatedness) mixed factorial design. The order of presentation for the sentences was pseudo-randomly arranged such that the visual probes did not consecutively bias spoken homophones. The order of presentation was counterbalanced across all participants.

All participants did the experiment individually in a quiet experimental room. Before the experiment, the experimenter explained the task in Cantonese to the listener. First, they were told that they would be hearing a sentence in two parts with a brief pause through a pair of headphone and then at the end of the sentence, they would see a Chinese character (visual probe) appeared on the computer screen. Their task was to carefully listen to the sentence and then to name aloud the Chinese character into the microphone as quickly and accurately as possible. Before the actual experiment began, they were given a practice session in which they heard a set of separate but similar sentences. The whole experiment took about twenty minutes.

**2.2 Results**

Mean response latencies, counting from the onset of the visual probe to the vocal response, as a function of Dominance, Reiteration and Relatedness are presented in the following figure. Errors (i.e. listeners named the visual probes with a word that is totally different from the target word) were very rare (approximately 0.03 across all conditions), and therefore error data were not analyzed further in the present study.

![Figure 1. Mean response latencies as a function of Dominance, Reiteration and Relatedness.](image)

**3. GENERAL DISCUSSION**

The present study further examines the processing of lexically ambiguous words in sentence context from a different perspective, i.e. the inhibitory processes of the different alternative meanings of the ambiguous words. We used spoken Chinese homophone in the present study as a rigorous test case because of the pervasive homophony phenomenon in this language. Clearly, the present results show that the corresponding sentence context aids the processing of Chinese homophones early on. These findings were consistent with other relevant studies in Chinese
sentence processing [5-10]. In addition, the present results demonstrated a strong dominance effect during the processing of the homophone. The dominance effect was sufficient to make an early selection among different alternative meanings of the homophone, as shown by the faster response time in DN and SR conditions than in SN and DR conditions respectively. This result is obviously against the assumption of modular approach of language processing; frequency effect could only occur at a late selection stage [1,2]. In addition, the reiteration effects clearly supported the inhibitory processes occurred rapidly following the first occurrence of the ambiguous word, i.e. the NP effects. More importantly, the inhibitory processes could sustain to a longer duration, about 2 seconds (around twelve syllables’ time) after the first appearance of the ambiguous word in a sentence context, which is in line with other relevant studies [14,15].

Other ongoing experiments were being conducted in our laboratory to further examine how the other variables, such as homophone density effect, relative frequencies information, and Inter-stimuli-interval (ISI), [25] influence the inhibitory processes of the ambiguous word during sentence processing in Chinese.

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5. REFERENCES