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指導教授：蔡介立博士
Advisor: Dr. Jie-Li Tsai

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REVISITING SEMANTIC PREVIEW BENEFIT: EVIDENCE FROM PROCESSING OF CHINESE TWO-CHARACTER WORDS

研究生：李孟璋　撰
Student: Bing-Tsiong Li

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REVISITING SEMANTIC PREVIEW BENEFIT: EVIDENCE FROM PROCESSING OF CHINESE TWO-CHARACTER WORDS

BY

Bing-Tsiong Li

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指導教授：蔡介立

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本研究探討中文讀者對於中文雙字詞的早期語意處理，特別要探討的是中文讀者是否能在凝視一個中文雙字複合詞之前，即可提取該詞的語意資訊。在中文的閱讀研究中曾經發現單字的語意資訊可以在該單字被凝視之前提取，不論是成詞的單字或是多字詞其中的組成單字。也有證據顯示中文雙字詞或雙字複合詞呈現在中央視野時的處理方式是整詞處理。由於事實上就詞長來看，雙字詞的詞類數量為中文詞類的最大宗，也是最常被使用的詞類，因此中文雙字詞語意處理的時間歷程便是本研究的研究目標。

實驗一旨在檢視雙字詞的語意資訊是否能和單字一樣，在被凝視之前即被提取。本實驗採用邊界典範（Boundary paradigm, Rayner, 1975），除了目標詞預視（identical preview）之外，本實驗亦包含語意相關預視（semantic-related preview）、語意無關預視（semantic-unrelated preview）及非詞預視（nonword preview）。實驗發現語意相關預視能促進目標詞的處理。然而和預視空間（preview space）及

預視時間（preview time）的交互作用則顯示語意預視效益（benefit）在預視空間較大的時候會隨著預視時間拉長而增加，在預視空間較小的時候，則會隨著預視時間漸減。

在實驗一中，語意關聯性的高低和該詞合理性（plausibility）的高低是共變的，因此這兩個要素構成一個混淆的因子。語意相關預視和語意無關預視之間的效果有可能來自語意關聯性的差異，或是來自在句中合理性的差異。合理性同時也能解釋在為何在實驗一中，不合理的語意無關預視在目標前詞（pretarget）上造成較短的閱讀時間。為了解決這項混淆的因子，實驗二因此採用對目標詞預視、語意相關預視、及語意無關預視都合理的句子。結果發現，語意預視的主要效果消失。然而交互作用的模式則顯示出，語意預視效益在較長的預視時間、較大的預視空間下仍會存在。但在較小的預視空間下，會隨著較長的預視時間而轉為耗損（cost）。實驗二的結果因此提供證據支持在沒有合理性的交互作用下，中文雙字詞的語意預視效應仍會發生。最後，兩個實驗的差異顯示在中文閱讀中存在合理性的預視效益，此結論和之前中文閱讀的研究結果一致。

Abstract

The present study investigates the early semantic processing of Chinese two-character words by Chinese readers. Specifically, whether Chinese readers are able to extract semantic information of an up-coming two-character compound as a whole when the word is yet being fixated. In Chinese, it has been demonstrated that semantic information can be extracted from a single character, whether it is a word or part of a word, before the character is being fixated. There is also evidence for whole word processing of foveally presented two-character compounds/words. Since two-character words actually constitute the majority of word type and are used most frequently in total, the time course of processing the meaning of such combination of characters during reading is then the goal of this study.

The first experiment aimed to examine whether semantic information of a two-character word can be extracted before it is fixated, as what have been found for single characters. Boundary paradigm (Rayner, 1975) was used, with identical, semantic-related, and semantic-unrelated words, as well as nonwords as preview. Semantic-related preview did facilitate target word processing. The interaction pattern of the effects with preview space and preview time, however, showed that semantic

preview benefit could increase with preview time with small preview space, but decrease with preview time under large preview space.

A possible confounding factor in the first experiment was the overlap between semantic relatedness and plausibility. The effect between semantic-related and semantic-unrelated previews could be of semantic or plausibility nature. Plausibility may also explain the shortened fixation duration found in Experiment 1 when implausible semantic-unrelated preview was presented parafoveally. Experiment 2 then solved this confounding by using sentence frames which are plausible for identical, semantic-related, and semantic-unrelated previews. In Experiment 2, main effect of semantic preview benefit disappeared, while the interaction patterns showed that such benefit existed for large preview space with long preview time, but became cost for small preview space with long preview time. The results of Experiment 2 thus provide evidence for semantic preview effect of Chinese two-character words without the interaction with plausibility. Finally, the discrepancies between the two experiments indicate the existence of plausibility preview benefit, which previous studies have suggested to exist in Chinese.

Chapter 1. Introduction

1.1 General background

During reading, the reader's final goal is to retrieve the meaning from each word in the text and eventually integrate all the information into the meaning of the sentence, then of the text. While most of the information was retrieved during relative steady fixation from the fixation point, it has been demonstrated that lexical information such as phonology or orthography can be extracted from the more peripheral vision called parafovea and benefit the ensuing processing. However, the extraction of semantic information parafoveally has been an issue in reading studies, not only because of its relative elusiveness to other preview benefit, but also because of its language-dependency. While alphabetic English and German, for examples, exhibit different behaviors and different degrees of effect size regarding semantic preview benefit, logographic Chinese also exhibit different reading patterns in semantic preview benefit when plausibility comes into play or when different units, such as semantic radicals, characters in words, single-character words, or two-character words are of interest. Previous studies have attributed the diverse findings to different processing load required by the different designs of the writing systems. The rigid spelling system in German requires fewer resources to resolve the texts to sounds, while English, as a writing system without rigorous correspondence

between spelling and sounds, retain fewer resources to recode the phonological information into meanings. The proposed explanation following this rationale for positive evidence of semantic preview benefit in Chinese then usually states that in Chinese, the orthography-phonology-semantic route is not followed. Rather, Chinese readers apply the strategy of orthography-semantic route, which requires fewer resources.

Aside from the diverging findings from different writing systems, there are also theoretical implications regarding the existence of semantic preview benefit. There have been models proposed to describe reading behaviors, with mechanisms determining reading times or fixation locations or such. Two most prevailing groups of models are serial attention shift (SAS) models and attentional gradient (GAG) models. The key difference related to this issue is the different saccade target selection between the two models. While SAS models assume deterministic saccade targeting, which may exclude words that have been semantically processed not to be the target, target selection of GAG models is not deterministic and allows semantic preview benefit to occur.

The issue of reading behavior brings up another line of investigation related to preview benefit. It has been proposed that preview benefit observed in previous studies may have resulted from preview cost brought by previewing an unrelated

preview, in addition to preview benefit, which is brought by previewing a related preview. This is supported by recent findings that the size and direction of preview effect may depend on how long the preview is parafoveally presented, how close the previewing site is to the preview, or how much foveal load is there during preview. The elusiveness of main effect of semantic preview benefit may be attributed to the interactions with these variables. While it may be necessary to investigate semantic preview effect with these variables, one may also gain insight into how these variables come into play during reading with such investigation.

1.2 Semantic preview benefit in Chinese

Previous studies of Chinese semantic preview effects have been focusing on the processing of single character. It has been found that semantics-related information from different levels of Chinese writing unit can be extracted parafoveally. These include sub-character radicals, non-word single characters, single-character words, and homographic characters that bear different morphemic meanings when embedded in different two-character words. In language use of Chinese, however, although characters are the basic units of writing, words can consist of only one character, or be composed of more than one characters. In most alphabetic writing systems, words are separated by spaces in between, but in Chinese, such multi-character words are not

visually separated. Among these words of different lengths, two-character words are the majority of word type and word token. The time course of resolution of meaning of such a word is thus of high importance, not only because these words are the majority of actual Chinese use, but because they lack explicit visual boundary when embedded in the sentences.

Yang (2013) addressed the issues with transposable two-character words, which, once transposed, are still words and may bear similar or different meaning to its original form. The reason for her choice of materials was to minimize orthographic difference between the targets and the transposed previews. The findings, however, suggested that Chinese two-character words exhibit plausibility effect rather than semantic preview effect. On the one hand, plausibility preview effect, which has also been demonstrated for single-character words (Yang, Wang, Tong, & Rayner, 2012), may indicate an ongoing integration process as early as during parafoveal preview. On the other hand, the effect observed in her study may suffer from other interference. First of all, the use of transposable words risks blurring the effect when the lexical representation of the transpose is activated. Second, her conclusion was drawn from comparing the effects between identical and transpose preview across different groups of materials, rather than directly from the benefit brought by previewing a related item compared to the unrelated one. Lastly, transposable two-character words only

represent a small part of Chinese lexicon or of Chinese two-character words. It remains unknown whether the effect found in the study is applicable to general two-character words. (Schotter, Lee, Reiderman, & Rayner, 2015; Yang, 2013; Yang et al., 2012).

1.3 Research questions

The present study therefore presents two experiments in investigating the time course of semantic access of Chinese two-character words and its interaction with the context. The study addresses the specific research questions as follows:

(1) Can semantic information be extracted from a general Chinese two-character word, rather than the specific type of transposable words, prior to the fixation of eyes on the word?

(2) Does semantic preview benefit stand when the pre-context supports both semantically related and unrelated previews?

The inference from the answer of the questions above will help us answer a third more general question of:

(3) How do Chinese readers process parafoveally the meaning of a two-character word during reading? That is, what is the time course of two-character word processing during parafoveal preview?

Chapter 2. Literature Review

2.1 Chinese compound words

2.1.1 Characteristics of written Chinese

Chinese is commonly written in square-like units called characters, mostly from left to right, with equal-size small spaces between each character. Characters can be inseparable combination of strokes by itself, or they can be composed of more than one radical, which either conveys part of the character's meaning or gives a clue to its pronunciation. Except for some stylistically manipulated characters, almost all Chinese characters correspond to one syllable in the oral language. Characters are therefore said to be the smallest writing unit of Chinese. The smallest unit to constitute a meaningful sentence, however, is word, like the other languages of the world. Chinese words can consist of one or more than one characters/syllables. While some of the single-character words are among the most frequently used words, such as 我 "I", 的, associative marker, and 是, copula, taking about 45.1% of occurrence in total (1922255 in 4264322), the majority of different word types go to two-character words, which account for 51.2% of word types (65228 in 127524) in Chinese, and 48.1% of word occurrence in use (2049601 in 4264322), as estimated from *Academia Sinica Balanced Corpus of Modern Chinese* (Academia Sinica Balanced Corpus, 2004).

Another characteristic relevant to this study is the disconnection between orthographic form and pronunciation of Chinese character, and thus of multi-character words as well. Beside the correspondence of one character to one syllable, characters have a less correspondence from their form to their pronunciation, unlike alphabetic writing systems. This characteristic has been mostly argued in previous studies to be the reason why semantic information in Chinese is easier to access. A more direct link has been proposed from orthography to meaning, with phonological representation as by-product during lexical access (Hoosain, 1991; Zhou, Marslen-Wilson, Taft, & Shu, 1999). However, the fact is that most of the characters in Chinese are phonograms (形聲), which encode their pronunciation loosely with a phonological radical. This resembles the situation in English, which also has a loose orthography-phonology correspondence. As will be argued the sections below, phonological information, like what is found in English, also played a role during Chinese reading.

2.1.2 Chinese two-character compounds

Most of Chinese words are composed of more than one characters. Their meanings can either be compositional from the constituent characters, or be independent of its components. For example, a two-character word in Chinese can be monomorphemic word, whose constituent characters have no independent meanings,

like 蟋蟀 “cricket” or 佝僂 “stooped”. They can as well be composed of two characters, each with its own meaning. For example 字典 “dictionary” is composed of 字 “character” and 典 “canon”. In the case of two-character compounds, although both characters are termed morphemes, the connection between the combination of morphemes and the meaning of the word can be transparent, like the example above, or opaque, like 津貼 “subsidy” from 津 “ferry” and 貼 “to stick”. For most of the time however, they are somewhere in between the two extremes. Since the only spacing in written Chinese is between characters rather than words, these meaningful component character in compounds can as well be demarcated as single-character words, though it may not lead to plausible parsing of the sentences. This arouses the question of how such compounds are processed and when the meaning of the entire compounds is accessed during reading. In research of such question as time course of processing, parafoveal processing has been used to probe the time course and the qualitative nature of the processing. Specifically, the process occurs when the visual presentation of the word falling in parafoveal vision during reading. The following section provides an introduction to this approach and its link to Chinese two-character compounds in this study.

2.2 Parafoveal processing

2.2.1 Parafoveal vision and perceptual span

During reading, as well as other visual task, most of the textual information is extracted from the foveal vision, which is a narrow area around that fixation point within a visual angle of about only 2° degree (Levi, Klein, & Aitsebaomo, 1985). Our eyes fixate at the fixation point relatively steadily, until a rapid saccade, during which our vision is mostly suppressed, that brings the eyes to another fixation point. When the eyes fixated at a point, visual information with less acuity is also extracted from an area of 2° to 5° degree from the fixation point. Such parafoveal vision results from physical conditions of our eyes and provides visual cues, for example the position of the next word, to guide eye movement. Meanwhile, this parafoveal vision is symmetrical around the fovea and is universal to all human. The range of peripheral textual information utilized in reading is further modulated by allocation of attention, which is adapted to fit different writing systems. Such range is termed perceptual span, which, unlike parafoveal vision, is asymmetrical due to the direction of reading and differs according to different writing systems. By limiting the text available from a window around fixation point (moving-window paradigm, McConkie & Rayner, 1975) and measuring whether reading is impeded, one can determine the perceptual span in a certain writing system. For example, it has been found that in English, perceptual

span extends 14 to 15 letters to the right and 3 to 4 letters to the left of the fixation, in accord with the fact the English reads from left to right (McConkie & Rayner, 1975, 1976; Rayner, Well, & Pollatsek, 1980). Since Hebrew reads from right to left, the pattern of perceptual span reverses, extending further to the left and shorter to the right (Pollatsek, Bolozky, Well, & Rayner, 1981). In Chinese, and in Japanese as well, with the use of characters, which are more condensed spatially, especially horizontally in comparison to alphabetic writing systems, the perceptual span is found to be 2 to 3 characters to the right and 1 character to the left of the fixation in Chinese (for Japanese, see: Ikeda & Saida, 1978; Inhoff & Liu, 1998). The presence of such a span implies that at least part of the information in this area is crucial to fluent, non-interrupted reading. The ensuing questions regarding parafoveal previews would then be the depth of processing of such extracted information and its role in fluent reading.

2.2.2 Preview benefit

In order to investigate such questions, boundary paradigm (Rayner, 1975) has often been implemented. In this paradigm, an invisible boundary is set at certain position in the sentence. The target at the right side (when the writing system reads from left to right) of the boundary is replaced by a preview until the eyes saccade

across the boundary (see Figure 1). When vision is suppressed during saccade, the preview switches rapidly back to the target word, and so the reader would not detect any changes. By doing so, although the reader reads the target correctly, s/he has received lexical information of another word from this region when fixating text prior to the boundary. If processing of a word starts as early when the word falls in parafoveal vision, using a non-identical preview would interrupt the preprocessing and resulted in longer fixation duration when the target is fixated. Such identical preview benefit is indeed widely reported in many studies and is regarded as an indication of existence of parafoveal preprocessing.

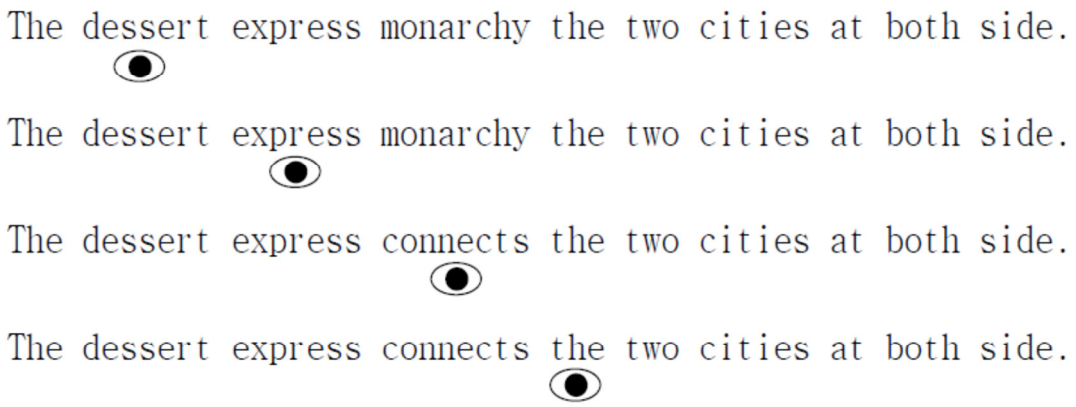


Figure 1. Display change in boundary paradigm with an invisible boundary between *express* and *connects*

Further, lexical processing can be decomposed into stages of processing or activation of different lexical properties, such as phonology, orthography, or meaning. As the terminal goal of reading is to access the meaning of each word and to integrate

them from merely visual input, orthographic information, for example, must first be processed in order to activate other representation, such as phonology, and to eventually access the meaning. By manipulating the overlap of lexical property between the preview and the target, one can infer from any ease of processing, as compared to an unrelated preview, about the depth of parafoveal processing. For example, a homophonous preview may yield a shorter fixation time on the target in comparison to a non-homonymous preview. This means that phonological representation of a word can be accessed when the word falls in parafoveal vision and thus shortens the ensuing foveal process. Such phonological preview benefit is well documented for example in English (Ashby, Treiman, Kessler, & Rayner, 2006), French (Miellet & Sparrow, 2004), and even Chinese (Liu, Inhoff, Ye, & Wu, 2002; Tsai, Lee, Tzeng, Hung, & Yen, 2004), which does not seem to encode phonological representation as systematically as alphabetic writing systems. Aside from homophonous preview benefit, preview benefit for onset syllable structure (Ashby & Rayner, 2004), orthography (McConkie & Zola, 1979; Rayner, McConkie, & Zola, 1980 among others), initial letter string (Inhoff, 1989), and morphology (Deutsch, Frost, Pollatsek, & Rayner, 2005).

Just like perceptual span, however, the presence of certain types of preview benefit varies across different writing systems. Since different writing systems encode

language information in different ways, reading strategy and depth of parafoveal preprocessing differs as well. The above-mentioned morphological preview benefit, for instance, is only found for Hebrew but not for English and Finnish, since constituent letters of morphemes in Hebrew can be interwoven across a words (Schotter, Angele, & Rayner, 2012). While those in English and Finnish are basically linearly aligned, such morphological process is inevitably overlapped with phonological or orthographic process.

2.2.3 Modulation of preview space and preview time

However, some may question whether the effects observed in the experiments were real preview benefit or preview cost, or they were the results of both effects at work. The notion of preview cost is that when a reader is previewing an unrelated word or random symbols, it may interfere with the reading since this is not a usual reading situation. However, simply measuring the difference in reading times for different previews does not distinguish between the two effects. Kliegl, Hohenstein, Yan, and McDonald (2013) then discussed the methodological possibilities to investigate into this issue with preview space and preview time. When the eyes fixate closer to the target before they foveally fixate it, larger portion of the target would fall into parafoveal vision, and the target would be closer to the foveal vision. The reader

can thus theoretically receive a better preview of the target. Preview time, on the other hand, is the time the reader spends during previewing. Operationally it can be defined as single fixation duration (SFD, the only first-pass fixation duration on a certain region) or gaze duration (GD, sum of all first-pass fixation durations on a certain region) of the pretarget under the situation where first-pass fixation on the target follows immediately the first-pass fixation on the pretarget. When better preview is provided, by means of closer preview space or longer preview time, increase in reading times for unrelated preview or random control indicates preview cost, while decrease for identical or related preview would be preview benefit.

There had been studies investigating the influences of these factors on preview effects. McDonald (2006) compared the preview benefit between identical previews and random letter strings in two conditions, in one of which the boundary was set at the end of the pretarget word, as in usual boundary paradigm experiments. In another condition the boundary was set between the 4th and 5th letters of pretarget word, which were all 9- or 10-letter long. He found that preview type was only a predictor for target fixation durations when the boundary was at the end of the pretarget. As for preview time, Yan, Risse, Zhou, and Kliegl (2012) investigated preview benefit in Chinese, following the design of Yan, Richter, Shu, and Kliegl (2009), which will be discussed later. They found that under longer pretarget SFD, as their operational

definition of preview time, increased the preview benefits. In another study by Tsai, Kliegl, and Yan (2012), where the operational definition of preview time was pretarget GD, preview benefits also increased with longer preview time.

Details of some of the studies mentioned above will be discussed later. For now, it seems clear that preview effects can be modulated by the factors of preview time and preview space. Further, according to how these factors influence the preview effects – by increasing the reading times with unrelated preview or by decreasing the reading times with related or identical preview, one could conclude whether such preview effects are due to preview benefit from related features or preview cost from unrelated features. Before further examining the studies in semantic preview benefit, the theoretical importance of such effect regarding the reading models will be discussed in the next section.

2.2.4 Reading models and semantic preview benefit

With accumulation of eye movement data, models have been proposed to fit and explain the data from our reading behavior. The two most successful and popular models are E-Z Reader (Rayner, Li, & Pollatsek, 2007; Reichle, Liversedge, Pollatsek, & Rayner, 2009; Reichle, Pollatsek, Fisher, & Rayner, 1998; Reichle, Pollatsek, & Rayner, 2006, 2007; Reichle, Warren, & McConnell, 2009) and SWIFT (Engbert,

Longtin, & Kliegl, 2002; Engbert, Nuthmann, Richter, & Kliegl, 2005), which belong respectively to serial attention shift (SAS) models and attentional gradient (GAG) models. According to E-Z Reader, attention is allocated at each word during reading, while in SWIFT, attention is distributed around the fixation point, where the level of activation of each word being attended rises simultaneously, since they are processed in parallel.

Although detailed specifications of each type of models are not the issue here, descriptions of their architectures are discussed for further discussion in semantic preview benefit. In E-Z Reader, detailed mechanism has been proposed about the time course and sequence of stages of visual processing, lexical processing, of attention shift, and of saccade planning. In E-Z Reader, lexical processing is assumed to be word-wise serial. A word is being processed when attention, not fixation point, is allocated to that word. There are two stages of lexical processing, L1 and L2. L1 is the early stage of lexical processing and is generally associated with processing of phonological and orthographic information. The completion of L1 will initiate L2, where deeper processing such as semantic processing takes place. The speed of each stage is influenced by factors such as word frequency, contextual information, and deviation of the word from the fixation point. While lexical processing is strictly serial, eye movement control in E-Z Reader is modulated by the state of lexical

processing. E-Z Reader assumes two cascading stages of saccade planning as well. The labile stage M1 can be cancelled and replaced by new saccade planning, but when this saccade planning enters the non-labile stage M2, the planned saccade will have to be executed at the moment when M2 is done, before any new saccade planning can take place. A new saccade planning is triggered by completion of L1 of a certain word n, termed $L1_n$. This new saccade planning aims at the next word n+1, termed $M1_{n+1}$. Following the architecture of E-Z Reader above, when the eyes fixate on a certain word n but the first stage of lexical processing on the next word n+1 ($L1_{n+1}$), for example, completes before first stage of saccade planning to the next word ($M1_{n+1}$) is done, $M1_{n+1}$ will then be canceled and replaced by $M1_{n+2}$, to the even next word. However, when $L1_{n+1}$ completes at the time when the saccade planning to the next word has entered the second stage ($M2_{n+1}$), it cannot canceled this saccade until $M2_{n+1}$ is done and the saccade is carried out. According to E-Z Reader, the first situation is the case of skipping (of word n+1), and in the second situation, preview benefit occurs. In the second situation, lexical processing of word n+1 completed before the eyes fixate, but not skip, the word, and that shall reduce the time spent on word n+1.

SWIFT model, on the other hand, assumes distributed attention, and the words within the attention window are being processed at different rate. The speed of word

processing, which results in the rises of what SWIFT terms activation levels, is decided by various factors, including the level of attention distributed to it. What differs SWIFT most from E-Z Reader is the temporal and spatial decision regarding saccade planning. In E-Z Reader, saccade planning has a specific goal at the beginning of M1, which is triggered by level of lexical processing (completion of L1). In SWIFT, however, saccades are autonomous generated without specific targets. Two stages of saccade programming are also suggested by SWIFT, first one labile followed by the non-labile stage. If there is no new saccade programming that intervenes and cancels the current labile saccade programming, at the end of the labile stage, saccade target will then be decided based on the activation level of each word. As for temporal variation in SWIFT, the base for saccade latency is the stochastic process in saccade generation, modulated by the intended saccade amplitude. Since saccade target is decided with the completion of labile stage, this modulation influences only the length of non-labile stage. Furthermore, saccade latency is modulated by foveal inhibition, which stems from difficult foveal words and aims to lengthened current fixation for further processing.

An important issue here is the difference in their predictions to certain phenomena, one of which would be semantic preview benefit. In E-Z Reader model, L1 only accounts for a low-level process of the word. In order to access semantic

representation from word *n+1*, $L1_{n+1}$ would have been done for $L2_{n+1}$ to reach a certain level of completion. Under this circumstance, $M1_{n+1}$ would have been canceled and a saccade to skip word *n+2* is being planned, resulting in skipping of word *n+1* without any detectable benefit on that word. Aside from mislocation of saccade, the only occasion for such preview benefit to appear is that by the time $L1_{n+1}$ is done, saccade planning has reached $M2_{n+1}$ (see Figure 2). The time for $L2_{n+1}$ processing before the eyes saccade to word n+1 is then shorter than $M2_{n+1}$, which is regarded as "formidable" by (Hohenstein & Kliegl, 2014). SWIFT model, on the other hand, does not exclude the possibility that a word whose semantic information has been activated becomes a potential target of saccade, since the selection is probability-based and is not only a function of activation level but also of other physical and lexical properties.

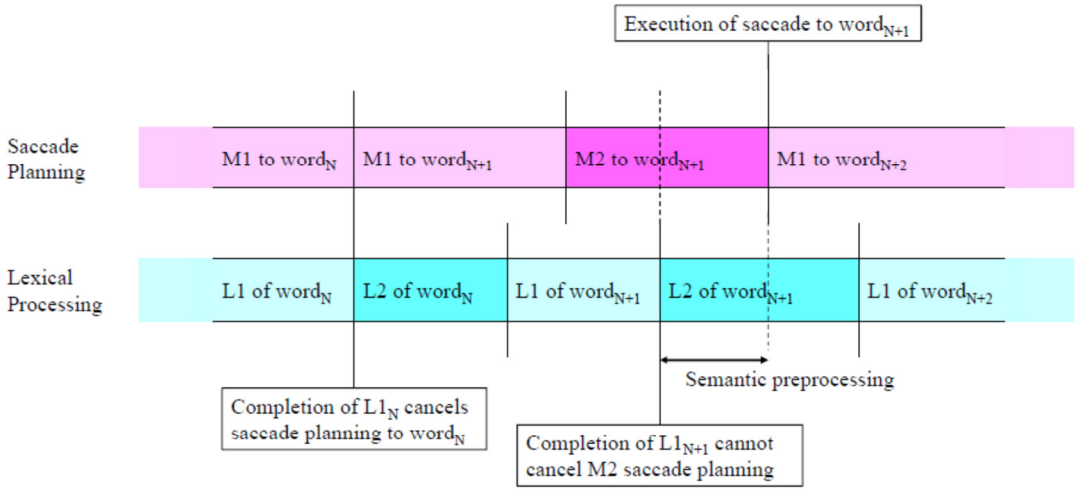


Figure 2. Semantic preprocessing predicted by E-Z Reader

Another reason for the hot debate for semantic preview benefit is its elusiveness in English. As stated above, a certain type of preview benefit can be a writing-system-dependent phenomenon, such as morphological preview benefit for Hebrew. Semantic preview benefit, however, has been disputed in English, the most-studied writing system. The following section will review the studies that provide evidence, null or positive, for such effect in English and in other languages as well.

2.2.5 Semantic preview benefit in English and other languages

Rayner, McConkie, et al. (1980) conducted an experiment investigating parafoveal semantic processing when there was no foveal load. Subjects were asked to name a word (e.g. *table*) initially presented in parafovea while semantic (e.g. *chair*) or unrelated (e.g. *chore*) preview initially took the place of the target word. The reaction times were the same for both types of previews, providing no evidence for semantic preview benefit. Even when the common boundary paradigm was used, studies in English (Rayner, Balota, & Pollatsek, 1986) and Finnish (Hyona & Haikio, 2005; White, Bertram, & Hyönä, 2008) provided no positive evidence for such preview benefit. The experiment manipulation in White et al. (2008) did yield some semantically related preview effects. In the study, the target was the second

constituent of long, two-constituent compounds, for example *vaniljakastike* "vanilla-sauce". Semantic-related preview, for example *vaniljasinappi* "vanilla-mustard", and semantic-unrelated preview, such as *vaniljarovasti* "vanilla-priest", along with identical and nonword preview (*vaniljaseoklii* "vanilla-*nonword*") were included in their experiment manipulation. Semantic related preview did not yield shorter fixation durations on the second constituent but resulted in longer go-past time (i.e. time from the first fixation on the target in first pass reading until the eyes fixated at the region to the right of the target) when the whole compound region was analyzed. There is no knowing what kind of process this rather late measure on the whole word rather than on the target area reflected. In another study conducted by Altarriba, Kambe, Pollatsek, and Rayner (2001), native Spanish speakers with fluent English ability were recruited in a boundary experiment, where there were identical previews, cognates (different from terminology in historical linguistics, cognate here is defined as orthographically and semantically similar word pair in different languages, e.g. *crema – cream*), pseudo-cognates, (i.e. orthographically similar word pairs with unrelated meaning, e.g. *grasa* "fat" – *grass*), non-cognate translations (i.e. semantically but not orthographically related word pairs, e.g. *dulce – sweet*), and unrelated previews. Preview benefits were found for identical, cognate, and pseudo-cognate preview but not for non-cognate translation preview. In

sum, preview benefit here in this study did not go beyond the effect of orthographic preprocessing. Recently, though, Schotter (2013) has demonstrated the presence of preview benefit in synonymous preview condition with neutral pre-context, while Schotter et al. (2015) found preview benefit for general semantic-related preview under special manipulation of the pre-context. The reason why only synonyms exhibit preview benefit under general neutral context was that semantic relatedness can be categorized into different sort of relatedness. For example antonyms like *happy* and *sad* may not seem related but they belonged to the same category of emotion. *Train* and *track* are related due to their high co-occurrence in the same schema of train transportation. Synonyms, although some argue that there are no real synonyms, formally refer to the same concept and therefore can be regarded as the most semantically related word pair/group. In the two studies (Schotter, 2013; Schotter et al., 2015), identical, synonymous, semantically related, and unrelated previews (e.g. *begin – start – ready – check*) were used, with different degrees of constraint in pre-context. In Schotter (2013), she not only found the synonym preview benefit, but also replicated previous results that non-synonymous semantic-related previews yield no preview benefit. In Schotter et al. (2015), however, they found that merely semantic-related previews provide preview benefit when the target was contextually predictable.

However, not all the alphabetic languages lack or have only elusive semantic preview benefit. Hohenstein, Laubrock, and Kliegl (2010) found semantic preview benefit in German with fast-priming paradigm, where semantic un-/related preview at target word *n* was presented only during a short time window since word *n-1* was fixated. After the limited preview time window, the parafoveal region was once again replaced by the target word. This then was the first study that demonstrated facilitation by previewing a semantic related word in alphabetic writing system. Later on, Hohenstein and Kliegl (2014) confirmed this results by using normal boundary paradigm without resorting to synonyms (e.g. *Riese* "giant" with semantic related preview *Zwerg* "dwarf"). Furthermore, Korean, an alphabetic writing system with one syllable written in one square-like box, also exhibits an effect similar to semantic preview benefit. Kim, Radach, and Vorstius (2012) manipulated the consistency of case marker, which indicate syntactic and semantic relations in Korean. They found an effect of correct and incorrect case marker in Korean. Although it was not an ordinary boundary paradigm experiment, where content words are used, it demonstrated that the syntactic function of the preview, which is of neither orthographic nor phonological nature, can be extracted from the preview.

To sum up, for alphabetic languages, English and Finnish have no semantic preview benefit. This may also include Spanish, as inducted from the lack of semantic

preview benefit in the bilingual study by Altarriba et al. (2001). On the other hand in German and Korean, various kinds of semantic preview benefit have been demonstrated. An explanation has been proposed (see Schotter, 2013 among others) to reconcile with the discrepancies. It has been argued that since English has a more irregular spelling, which adopts a loose correspondence between the orthography and phonology of the language, more resources are dedicated to process orthographic information to obtain phonological representation during lexical processing, including previewing. German, on the other hand, has a more rigid spelling system and thus more resources are available for semantic preprocessing. Such an explanation cannot explain the findings in Finnish and Spanish, since they also adopt rigid spelling system. However, it is tempting for such studies in Chinese, since semantic access in Chinese, as argued above, does not require the phonological stage, which spares more resources for the follow-up semantic processing. The following section will then review the findings for preview processing in Chinese.

2.3 Parafoveal processing in Chinese

2.3.1 Scope of effects

As described above, Chinese scripts can be decomposed into different levels of unit. Sentences are composed of words, words of characters, characters possibly of

radicals, and radicals of strokes. Except for the characters in monomorphemic words, which do not have their own character meaning, most of the characters have its own meaning and can stand alone as single-character word or serves as morpheme in multi-character words. Take a two-character word 可口 /ké kǒu/ "tasty" for example, each character 可 /kě/ "worthy" and 口 /kǒu/ "mouth" has its own meaning related to but distinct from the compound. And although orthographically a compound is identical to the combination of its constituents, there were experiments suggesting a distinct representation of compound word other than those of its constituents (e.g. 丁国盛 & 彭聃龄, 2006). When considering single-character word, these properties of character level and of word level are then overlapped. Therefore, when considering which property of the preview is extracted, the scope of the property has to be well-defined. While there may be other studies that defined "lexical" property at character level, the term is defined at word level in this study and is thus applied to the property of two-character or single-character word as a whole but not constituent character of the two-character compounds. With clear definition of level of effects, the following section will introduce the preview benefits found in reading Chinese.

2.3.2 Preview benefit in reading Chinese

What seems to be universal to all the writing systems of the world are

phonological and orthographic preview benefit, as noted above. These effects have been found in English and other languages. Chinese is no exception. Phonological and orthographic preview benefit has been found (Liu et al., 2002; Tsai et al., 2004). As for the controversial semantic preview benefit, since Chinese is believed to have a more direct link from orthography to semantic. It is predicted that semantic preview benefit should be easier to observe in Chinese. The situation, however, becomes complicated when Chinese is being discussed, since both character and word can have its own meaning, plus the morphemic status of constituent character in multi-character words.

Most of the studies so far have focused on preview of single character. Yan et al. (2009) and Tsai et al. (2012) selected integrated characters (i.e. characters that cannot be further decomposed into radicals, for example 羊 "sheep") as their targets and previews respectively in simplified and traditional Chinese. Their studies demonstrated semantic preview benefit along with orthography and phonology preview benefit in Chinese. Their findings, however, were character-based since their target characters were embedded as the first character of two-character compounds. Such a morpheme preview benefit is further confirmed in the second experiment of Yen, Tsai, Tzeng, and Hung (2008). The experiment used homographic single-character morphemes that can only be disambiguated in the context of matrix

compound. For an example in their design, the target word 戒菸 (“quit” and “smoking”) “to quit smoking” would have preview with the same morpheme such as 戒除 (“quit” and “get rid of”) “to give up a hobby”, or the one with a different morpheme 戒備 (“guard against” and “prepare”) “to guard against”. Their results showed that readers could disambiguate the morphemes when there was enough preview time. As for word-level semantic preview benefit, Yang et al. (2012) used single characters as their targets, but they were single-character words when embedded in the sentence frame, such as the experiment sentence in their study below:

(1) 陳健拎著一箱鞋來到我經營的小店裡。
“Chen carried a box of shoes to the store I’m running.”

Furthermore, their materials included both integrated and compound characters (i.e. characters that can be further decomposed into sound- or meaning- bearing radicals, for example 悲 /bei/ “sad”, composed of semantic radicals 心 “heart” and phonetic radicals 非 /fei/). By doing so, they found semantic preview benefit, but only when the preview fit plausibly into the context. They also found plausibility effect, which was the contrast of semantic-unrelated-implausible preview to the average of semantic-related-plausible and semantic-unrelated-plausible previews. Another study by Yan, Zhou, Shu, and Kliegl (2012) investigated the influence of semantic radical’s influence on semantic preview benefit. They found that transparency of mapping

between the meaning of semantic radical and the meaning of the character can influence the size of semantic preview benefit. Their results, in addition to Tsai et al. (2004), demonstrated that sub-character information, either phonological or semantic, influences preview as well. However, the targets of the study were also characters embedded as the first character of two-character words. On a strict standard, except for Yang et al. (2012), the aforementioned studies were all sub-lexical preview benefit since the benefit came from components of words. The following section will then introduce the studies investigating into processing of two-character compounds per se.

2.4 Processing of Chinese two-character compounds during reading

2.4.1 Prominence of compounds

The reason why studies of normal reading have been focused on character-level processing is conceivable, since in written Chinese, the spaces are used to separate characters but not to demarcate words. However, there were studies that showed the special status of two-character words during reading. Tsai, Lee, Lin, Tzeng, and Hung (2006) found effects of word frequency and neighborhood size of Chinese two-character compounds. Words of higher frequency or with more neighbors, which are defined in the study as words that share the first character, were read faster. Furthermore, skipping rate was also higher with words with large neighborhood size.

This indicates that during preview, in which information concerning skipping is retrieved, the property as a word is accessed. Li, Gu, Liu, and Rayner (2013) also reported such word-ness effect. In their experiment series, readers only had a limited window of two characters. Reading was interrupted more when whole-word vision was blocked than when whole words were given in the two-character window. Further under another experiment setting, readers could adapt themselves unconsciously to the experiment manipulation in order to obtain a whole-word window. Other studies also showed that character processing can be influenced by internal relationship of two-character compounds. To be specific, when the two characters were more closely bound together, for example for monomorphemic words, or compound words with low-frequency first constituent, which would constrain the possibility of the second constituent in Chinese, showed a tendency toward parallel or early processing of the second constituent (Cui, Drieghe, et al., 2013; Cui, Yan, et al., 2013). More directly, in the first boundary paradigm experiment of Yen et al. (2008), two-character words were selected as target. In the experiment, previews included identical words, unrelated words, and pseudowords, whose constituents were real characters but for which the combination had no meaning. It turned out that previewing pseudowords resulted in less skipping than related word, and previewing identical words resulted in shorter fixation duration. This demonstrated that a two-character word can be

previewed as a whole. Since two-character words are the majority of word type in Chinese and one of the most frequently-used word type, alongside with single-character words, and in addition, the boundaries for such words are not explicitly marked, it would be interesting to ask the same question of semantic preview benefit under the context of two-character words as have been done in alphabetic system or as single-character words in previous research.

2.4.2 Parafoveal processing of two-character words

Since the initial character and the compound overlapped entirely on their orthography and almost entirely on phonology, with only the exception when tone sandhi occurs, the time course of semantic access of compounds would be more interesting a question. Recently Yang (2013) conducted two experiments to investigate two-character compounds. A special kind of compounds was used in her studies to minimize the orthographic differences. That is, the compounds whose transposition of the two characters is another compounds. This sort of compounds can further be categorized into two sets. There are some compounds that are synonymous to their transposed counterpart. These were termed Synonym Transpose (ST). For example, both 远久(遠久) and 久远(久遠) mean "(chronically) distant", and thus constitute a ST pair. The other set then have compounds with meaning different from

its transpose, termed Different Transpose (DT). These compounds include, for example, 画笔(畫筆) “brush” and 笔画(筆畫) “stroke”. In her first experiment, readers spent less time on the target in identical condition than transposed condition for DT condition, but not for ST condition. This comparison was not usual among previous studies, and so hereafter, such and similar effects would be termed transposed (or the preview type in discussion) preview cost, since it means the price that is paid when previewing something different from the original text. While unorthodox, the presence and absence of such effect did demonstrate that reading times for previewing semantic-related transposed word were closer to the reading times with identical preview, than the reading times for transposed preview with unrelated meaning. However, when conventional comparison for presenting semantic preview benefit was inspected, differences between reading times of transposed condition and unrelated control condition were also smaller for ST condition. This could mean that previewing a semantic-related word provides less benefit than previewing a word without the meaning related to the target.

2.5 Transposition

Aside from the conflicting results with comparisons with different baseline, the use of transposable words may have its own problem. The effect of scrambling

constituents in a word has been found to be both facilitative and inhibitory. For alphabetic writing system such as English, parafoveally transposing adjacent letters facilitates target processing more than substituting one letter at the corresponding position (Johnson, Perea, & Rayner, 2007). However, when the transposed-letter string constituted a real word and presented foveally as prime in fast priming experiments, the effect became inhibitory (Johnson & Dunne, 2012). In Chinese, however, things were different. Since the units of transposition are mostly meaningful characters, while those in English are merely letters. Regarding the proportion of alternation in orthographic representation, among these studies in English, the shortest words appeared in Johnson and Dunne (2012), which were 4-letter long. The transposition of two letters in such words resulted in 50% of visual difference. Transposition two characters in Chinese, however, basically resulted in no orthographic overlapping to the original word. Therefore, one may expect different results of processing transposition in Chinese. For example, when transposed two-character word served as prime, the effects could be facilitative under a certain SOA (157 ms) (丁国盛 & 彭聃龄, 2006; 彭聃龄, 丁国盛, 王春茂, Taft, & 朱晓平, 1999). What is common to both Johnson and Dunne (2012) and 丁国盛 and 彭聃龄 (2006) is that in both studies, facilitation induced by nonword transpose was robust.

Their studies, however, dealt with foveal priming but not parafoveal preprocessing. There is no knowing whether in parafoveal region, a transposable preview could activate its transposition during reading. In a study by Sung and Tang (2007), they reversed adjacent characters in the sentences and provided only limited time (2 seconds) for their subjects to read the sentence. The subjects were later to report whether they observed any reversed error or not. Although reading was impeded, as inferred from longer reading times, subjects might also fail to report the reverse, especially when the reverse occurred within a two-character word. Therefore, although with impedance, the original word of reversed character string seemed to be activated and hinder the reverse judgment. This should be taken into consideration in examining the effect found in Yang (2013). When both words of transposed characters and of original character order are activated, further process load is required for selection, especially for items with similar meanings due to similarity-based interference (see Lewis & Vasishth, 2005).

Another problem with transposable words is that they represent only a relatively little part of Chinese two-character words. Therefore, it is of interest whether the findings with these words can be generalized to common two-character words. In sum, the design of Experiment 1 has the following purposes: (1) To generalize the character-based semantic preview benefit observed in previous studies

in Chinese to two-character words, (2) to avoid the unknown influences brought by transposed previews and, (3) to investigate the semantic preview benefit of two-character words in a more general way. Accordingly, the design of Experiment 1 will then use semantically related two-character compound words as preview, without any orthographic or phonological overlapping. By doing so, any parafoveal preview benefit observed will be the result of accessing the meaning of the two-character compound.

Chapter 3. Experiment One: Parafoveal semantic preprocessing of Chinese two-character compounds

Experiment 1 was designed to assess whether previous findings about semantic preview benefit can be generalized to two-character compounds. In this boundary paradigm experiment, the targets were two-character compounds in traditional Chinese. Before readers' eyes made the saccade across the boundary between the target and the word before, they might receive one of the following four previews: (1) Preview that was identical (ID) to the target, (2) word that was semantically related (SR) to the target, (3) word that was semantically unrelated (UR) to the target, or (4) two random real characters that did not constitute a real word (nonword condition, NW). Nonword condition was designed following Cui, Yan, et al. (2013) and Yen et al. (2008), in which lexical effect was observed. Non-lexical items may cause longer fixation time. The difference between the reading pattern of SR and UR would be semantic preview benefit. The effect between ID and SR is not expected since in previous studies (Yang, 2013; Yang et al., 2012), such effect was barely significant when embedded under plausible context. Lastly, the effect of difference between UR and NW observed in previous studies (Cui, Yan, et al., 2013; Yen et al., 2008) is expected.

3.1 Method

3.1.1 Participants

Fifty-two students or members (41 females and 11 males) of age ranging from 18 to 32 (average = 21) from National Chengchi University community were recruited for the eye-tracking experiment. Participants were paid for their participation. All of them were native speaker of Mandarin Chinese in Taiwan, with normal or corrected-to-normal vision. None had participated in any norming study.

3.1.2 Materials

Seventy-two two-character compound words were selected as target words, whose frequency ranged from 1.0 to 13.4 per million words, averaging 6.0, as estimated from *Academia Sinica Balanced Corpus of Modern Chinese* (Academia Sinica Balanced Corpus, 2004). They all consisted of two characters with their own meanings, that is, they were all compounds. Another 72 two-character compounds were selected as SR previews. Their meanings were matched to the corresponding target word. According to the findings of previous studies (Cui, Drieghe, et al., 2013; Cui, Yan, et al., 2013), the process of Chinese compounds seems to be serial in nature, and is modulated by the relation of the constituents. Therefore, in order to ensure that readers retrieve the meaning of the compounds, the highest-frequency neighbors were

selected so that the recognition of the first constituent could facilitate the processing of the whole word. Their frequencies were not matched to the targets, since they were to be compared with previews without related meanings. However, their frequencies were controlled from 10.0 to 60.0 (M = 26.5, SD = 1.46) per million words to avoid frequency effect (Rayner & Duffy, 1986).

UR previews came from the same set of words as SR previews. They were re-matched so that their meanings were unrelated to those of their correspondent target words. Another set of previews was set up as NW control. They all constituted of two real characters, but the combinations were all meaningless.

All of SR, UR, and NW previews shared no character with the corresponding target, nor did they shared the same pronunciation and onset phoneme with their target, in order to avoid any phonological or orthographic preview effect (Liu et al., 2002; Tsai et al., 2004). About one-third of the materials were verbs, while others were noun. The number of strokes of first character (C1), second character (C2), and total strokes were matched. One-way ANOVAs were conducted to compare these properties of each group of words. There were no significant differences between the groups (Fs < 3, ps > .1). Table 1 presents the properties of each group of previews.

Table 1

Means and standard errors of word frequency per million, C1, C2, and total strokes of the two constituents of each preview condition in Experiment 1

	Targets and ID prev.	SR/UR prev.	Non-word prev.
Word example	清早 "early morning"	凌晨 "daybreak"	居備
Word frequency	5.99 (0.44)	26.52 (1.46)	-
C1 strokes	10.71 (0.54)	11.97 (0.52)	10.92 (0.37)
C2 strokes	10.10 (0.50)	9.43 (0.56)	10.46 (0.34)
Total strokes	20.81 (0.65)	21.40 (0.72)	21.38 (0.44)

A sentence frame was construction for each target word. The onset of the two-character region of interest lies between the 12th and 18th character in the sentences. None of the target words were at the end of the sentence, nor would they be preceded or followed by any punctuation marks, since they were surrounded in the front and in the back each by a two-character word. All the sentences were within a length of 27 characters including punctuation marks, and were presented as one line on the screen. An example of such sentence with different previews underlined is given below, following the order of identical, semantic related, semantic unrelated, and nonword preview:

(2) 小黃平常下班的時間都是每天清早/凌晨/豬肉/居備太陽還沒出來之前。
"Huang usually gets off work at early morning/daybreak/pork/*non-word* before the sun comes up."

Four experimental lists of trial sequence were established in a fixed random fashion. Each list consisted of 72 trial sentences and 8 fillers, split into four blocks. Each block contained 4 trials for each of 4 conditions, plus 2 trials from one of the conditions. With 2 filler trials which were fixed-randomly scattered in the block, there

were totally 20 trials in one block. Before the experiment trials, four exercise trails were presented to familiarize the participants with the procedures of reading and comprehension questions.

Prior to the eye-tracking experiment, a norming study was conducted to ensure that meaning relatedness between each group to be so as designed. In addition, predictability and plausibility of each preview with the pre-context were also assessed in the norming study. Nonword previews were excluded since they had no meaning at all. Table 2 lists the results of each norming study.

Table 2

Means and standard errors of rated results of the norming study for Experiment 1

	ID	SR	UR
Meaning relatedness	-	5.22 (0.09)	1.39 (0.05)
Word Predictability	0%	0%	0%
Plausibility	5.91 (0.08)	5.25 (0.15)	1.84 (0.07)

3.1.2.1 Norming study: Meaning relatedness, sentence predictability, and sentence plausibility

This norming study was designed to determine the following three things: (1) Meaning relatedness between the target and SR or UR previews, (2) how predictable ID, SR, and UR previews were under the pre-context, and (3) how plausible these previews were when embedded in the pre-context. Thirty students of National

Chengchi University were recruited and paid for the rating. None of them participated in the eye-tracking experiment. They were all native Mandarin Chinese speakers.

Six fixed lists were created by combining one of the two lists for semantic relatedness and one of the three lists for sentence predictability and plausibility. The two semantic-relatedness lists contained 72 target words, each paired with either a semantically related compound or a semantically unrelated compound. Each semantic-relatedness lists contained equal amount of ID-SR and ID-UR pairs. The three sentence lists contained all 72 sentence frames as well. Sentences in each list were embedded with equal amount of ID, SR, and UR previews and were balanced across the three lists.

Subjects were randomly assigned to one of 6 the list. First they were asked to rate the semantic relatedness of each word pairs in the semantic-relatedness sub-list on a 7-point scale, where 1 means completely unrelated and 7 means extremely related. Once they had completed the semantic-related part, the instruction on the next sub-list was given and they proceeded to the next part. At the beginning of each trial in the sentence sub-list, only sentence fragment prior to the target region was visible. Subjects were asked to write down a two-character word which they thought to be suitable for the sentence to precede, but not necessarily to end the sentence. Once a two-character word was written, the sentence frame embedded with a certain type of

preview was shown. Their task then was to judge the plausibility of this sentence fragment on the 7-point scale. Only when they fully answered one trial, i.e. when they completed the plausibility rating, would the pre-context of next trial showed up. The full list was design in the way that they had to write their answers obligatorily serially from the top of the list. Three practice trials preceded each sub-list to familiarize the subjects with the task.

The results of semantic relatedness judgment showed that the meanings in each ID-SR pair were matched and those in each ID-UR pair were not. The meaning relatedness of SR words to the target were all above 3.5 (M = 5.2, SD = 0.09), while that of UR words were all below 3.5 (M = 1.4, SD = 0.05) and were distinct from that of SR ($F > 3$, $p < .05$).

Predictability data from 10 of the participants were discarded due to mal-control of the rating environment. As for the data of the rest of the participants, while for some pre-contexts, subjects did have a bias toward a specific word and not for others, none of these predicted words were the target or belonged to any group of previews. For every sentence frame, no words from preview or target set were written. Thus it was safe to say that although the sentences had different constraints (from as low as 10% to 75%), for each sentence frame, none of the selected previews were predictable.

As for sentence plausibility, sentences were all plausible when embedded with identical preview (all above 3.5, M = 5.9, SD = 0.08), and so were those with SR preview (M = 5.3, SD = 0.15). Those with UR preview, on the other hand, were all implausible with rated plausibility all lower than 3.5 (M = 1.8, SD = 0.07) and were distinct from SR preview ($F > 3$, $p < .05$). Again, this rating involved none of nonword previews since the results were expected to be zero predictable and total implausible.

3.1.3 Apparatus

An Eyelink (SR Research, Osgoode, ON, Canada) 1000 Desktop Mount eye-tracking system with a sampling rate of 1000 Hz was used to record gaze positions during the experiment. Eye movements were recorded from the dominant eye, though viewing was binocular. Sentences were displayed in a single line at the middle of the screen on a 19-in. ViewSonic PT795 monitor (1024×768 pixels in resolution and 100 Hz in vertical refresh rate).

The experimental program was implemented in Matlab (MathWorks, Natick, MA) using the Psychtoolbox 3.0.10 (Brainard, 1997; Pelli, 1997) and the Eyelink toolbox (Cornelissen, Peters, & Palmer, 2002) to display the stimuli and to communicate with eye-tracker core libraries. Detecting the eye position across the

boundary took 3 to 4 ms, and an additional 8 ms (maximum) was needed to complete the display change.

The sentences were displayed in black on a light gray background. The size of each character presented on the screen was 32×32 pixels, with a four-pixel-wide space between each character. The viewing distance was 70 cm, and so the character width and the space before it subtended a visual angle of 0.9°.

3.1.4 Procedure

The entire experiment was conducted in a dimly lit and noise-attenuated room. Prior to the experiment, the participants were tested for their dominant eye and then sat in front of the monitor. Each of them was assigned to one of the four experimental lists and was given both oral instruction and the instruction presented on the monitor. After the instruction, the reader performed a nine-point or five-point calibration and validation procedure to ensure the accuracy of eye movement recording. Given a successful calibration, the experiment started out. At the beginning of each trial, the participant was asked to fixate her/his eyes on a cross at the location where the first character of the sentence would be displayed. Once they fixated on the cross, the cross would vanish and the sentence would be displayed. The participant was instructed to read the sentence at her/his own pace. When s/he understood the meaning of the

sentence and was ready to move on, s/he would fixate the eyes on a right-most cross, located below the last character of the sentence, and press a button simultaneous to end the display. Around one third of the sentences were followed by a true-false comprehension question. The participant answered the question based on the sentence s/he just read by pressing either the left button "yes" (是 /shì/) or the right button "no" (否 /fǒu/). Feedback was presented on the monitor after s/he gave the answer with the button. The entire experiment procedure lasted about fifty minutes.

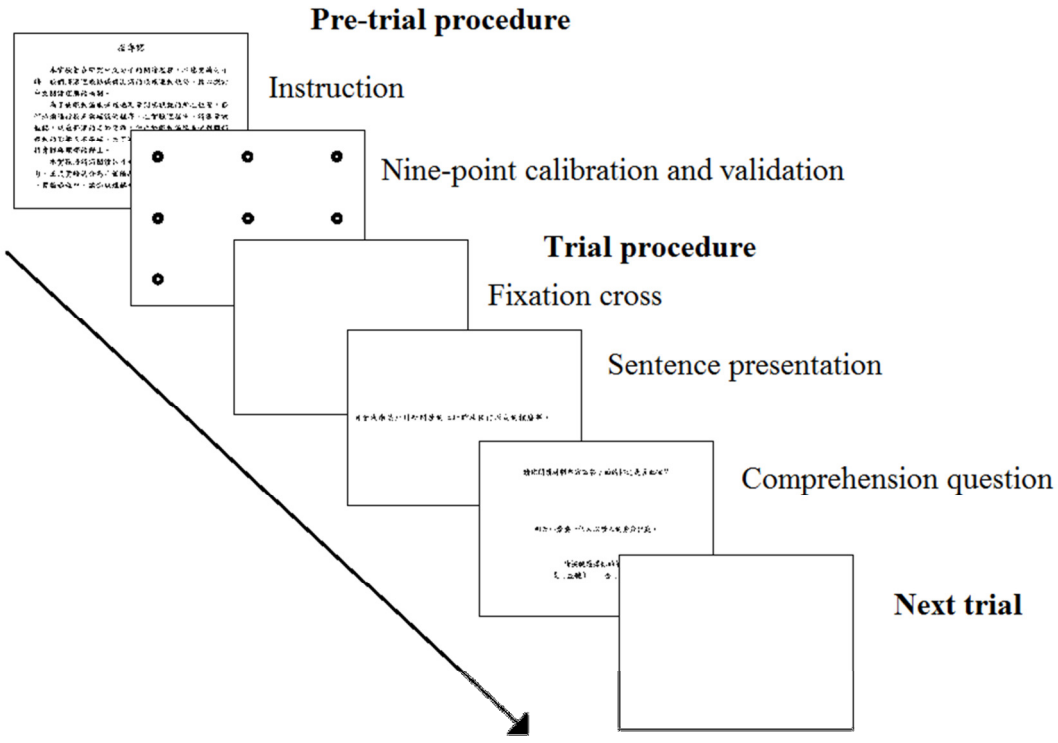


Figure 3. Eye-tracking experiment procedure in this study

3.2 Data analysis

Three regions of interest (ROIs) were subject to analyses of eye movements: target word region, pretarget word, and posttarget word region. All of these were two-character region. Fixation durations and probability measures on the ROIs were analyzed.

In this study, only early eye movement measures were subject to the analyses. These include first-pass measures such as FFD or skipping rate, among others. The reason for the selection is that this study was designed to probe the process of lexical activation rather than sentence comprehension. The rationale is based on two assumptions that have been shared by many eye-tracking studies, namely immediacy-of-processing hypothesis and eye-mind hypothesis (Just & Carpenter, 1980). While these hypotheses were not without challenges or revisions, they built up the basic idea that fixation on a certain region reflects the processing of the text information in that region. Given that reading includes a series of processes from raw visual input of text to sound and meaning (early lexical activation), to disambiguation, integration of meanings, and eventually to comprehension (late context integration), early measures could reflect the loads of early processing including semantic retrieval. The eye movement measures used in this experiment then are listed below in (3), and the calculation of each eye movement measure is depicted in Table (3).

(3) The definition of the eye movement measures used in this study:

i. First Fixation Duration (FFD): the duration of the first fixation in the ROI independent of the number of first-pass fixations made in the region

ii. Single Fixation Duration (SFD): the duration of the only first-pass fixation in the ROI

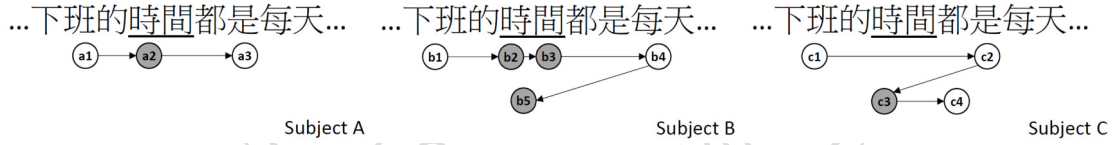
iii. Gaze Duration (GD): the sum of all first-pass fixations in the ROI before moving out of the region

iv. Skipping Rate (SKIP): the probability of skipping a word during first-pass reading

v. Refixation Rate (ReFix): the probability of refixating a word during first-pass reading

Table 3

The fixation patterns and corresponding calculation of each eye movement measures used in the present study



	Subject A	Subject B	Subject C
First Fixation Duration	a2	b2	no
Single Fixation Duration	a2	no	no
Gaze Duration	a2	b2+b3	no
Skipping Rate	no	no	yes
Refixation Rate	no	yes	excluded from the calculation

Shaded fixation points indicate fixations on the target word 時間 "time"

Nine participants observed more than 10 display changes, and so data of these participants were excluded from the analyses and were replaced with new qualified

data. Data of another one participant was treated the same way due to high blinking rate. Trials were also deleted from the analysis for the following reasons: (1) Fixation duration on the ROI was shorter than 80 ms or longer than 800 ms. (2) There was a blink on the ROIs. (3) Fixation fell out of the range of ROIs. (4) The fixation was at the beginning or at the end of the trial. (5) Display change occurred after the eye fixated on the target region. Overall, for the data of first-pass measures, 6.9% (237) of trials were removed based on these criteria. For each duration measures, 28.1% (966), 41.8% (1438), and 29.4% (1011) of trials were removed respectively from the database of FFD, SFD, and GD. Further, in order to launch analyses with preview time and preview space as covariates, trials were further excluded when its preview space or the preview time was unavailable. Preview time utilized pretarget single fixation duration. The criterion for valid preview time was valid pretarget's single fixation followed immediately by target's first-pass reading. Preview space utilized launch site into the target. The criteria for launch site was set to be within 2.5 characters prior to the target word region, not only because a majority of launch site fell in this range, but because this is the average size of perceptual span in Chinese (Inhoff & Liu, 1998). Overall, 35.8% of data were retained for the analyses.

The present study used linear mixed-effect model (LMM, Baayen, Davidson, & Bates, 2008) for estimation for duration measures, and generalized linear mixed-effect

model (GLMM) for probability measures, both with crossed random effects of subjects and items. The *lmer* function from the lme4 packages (Bates, Maechler, Bolker, & Walker, 2014) was utilized in the R 3.1.2 environment for statistic computing and graphics (R Development Core Team, 2014). Based on estimation with *boxcox* function (Box & Cox, 1964; Venables & Ripley, 2002), duration measures were first log-transformed before entering the models. While the results of analyses were presented with log-transformed value, graphs and raw data will be presented in normal scale. For significant ($p < .05$) and marginal significant ($p < .07$) effects, regression coefficients (*b*s), standard errors (*SE*s) will be reported. Alongside, while *t*-values are to be reported in tables for duration measures, significance level of each of these effects was estimated using Monte Carlo simulation with *confint* function in the R environment and will be reported as well. Probability measures, on the other hand, will be reported with *p*-values. Sliding contrast was used to test SR preview cost, semantic preview benefit, and lexical effect, which are respectively means or probabilities of SR - ID, UR - SR, and NW - UR. As described above, preview space, preview time, and their interaction were used as covariates in the analyses of target and posttarget region. Preview space was also used as a covariate in the analysis of pretarget region.

3.3 Results

3.3.1 Pretarget region

Pretarget region is the two-character region before the target word. In addition to item and subject as crossed random effects, the analyses in this area included preview space as a covariate, which is the same set of data as launch site of target word but within two-character range. This criterion difference is explicable: In order to assess how preview of the next word affects pretarget region, in other word, parafoveal-on-foveal effect (POF) (see Schotter et al., 2012 for a summary), only the situation is considered where fixation on the pretarget is followed by a fixation on the target. When the pretarget region has its first-pass fixation but launch site for the target region is beyond two characters, this implies that regression occurred after pretarget region was fixated during first-pass reading. Since the nature of the influence of this regression is largely unclear, this portion of data was left out. In addition to preview space, since pretarget word frequency was not controlled at the first place, log-frequency of pretarget words was also used as a covariate in the statistic model.

The results of analysis of pretarget region are listed in Table 3. For duration measures, SR preview cost did not reached significance. There was a semantic POF for FFD (b = -0.056, SE = 0.028, $p < .05$), and it was marginal for SFD (b = -0.058,

SE = 0.030, $p < .07$) and GD (b = -0.068, *SE* = 0.035, $p < .07$). What should be noticed is that the regression coefficients for this effect are negative. That is, previewing something semantically related will increase the processing load at foveal vision. Lastly, lexical effect was not significant. Neither probability measures reached significance for all effects of interest.

In order to investigate the details of this semantic effect, fixation times for each condition were linearly regressed and plotted against preview space (Figure 4). The graphs show that, when eyes fixated more closely to the target, preview times increase. This increase was slower for UR words, resulted in longer preview fixation times when previewing ID, SR, and surprisingly non-words.

Table 4

Results of analyses of pretarget fixation duration in Experiment 1 and the interactions with preview space (p.s.) pretarget log word frequency (w.f.)

	FFD			SFD			GD		
	b	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
(intercept)	5.48	0.02	264.69***	5.48	0.02	249.33***	5.54	0.02	227.54***
SR - ID	0.03	0.02	1.15	0.03	0.03	1.11	0.03	0.03	1.08
UR - SR	-0.06	0.03	-2.27*	-0.06	0.03	-2.18*	-0.07	0.03	-2.28*
NW - UR	0.05	0.03	2.05*	0.04	0.03	1.57	0.07	0.03	2.13*
word freq.	-0.01	0.01	-2.57*	-0.01	0.01	-2.59*	-0.02	0.01	-2.83**
prev. space	0.04	0.01	3.83***	0.04	0.01	3.57***	0.08	0.01	6.32***
SR - ID :wf	0.01	0.01	0.55	0.01	0.01	1.19	0.01	0.01	0.91
UR - SR :wf	0.01	0.01	1.01	0.01	0.01	0.88	0.01	0.01	0.52
NW - UR :wf	-0.03	0.01	-1.83	-0.02	0.02	-1.26	-0.02	0.02	-0.88
SR - ID :p.s.	-0.05	0.03	-1.63	-0.05	0.03	-1.51	-0.06	0.03	-1.73
UR - SR :p.s.	-0.05	0.03	-1.70	-0.07	0.03	-2.33*	-0.07	0.04	-1.80
NW - UR :p.s.	0.04	0.03	1.14	0.04	0.03	1.14	0.06	0.04	1.60

***$p < .005$, **$p < .01$, *$p < .05$, +$p < .07$.

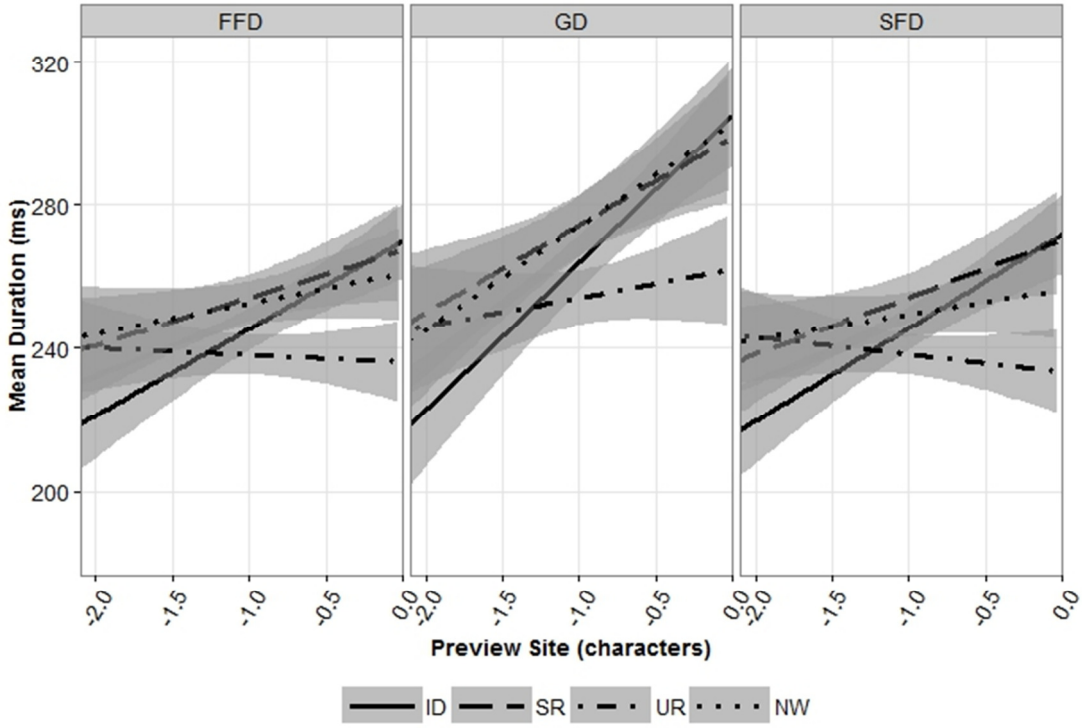


Figure 4. Estimated FFD (left panel), SFD (right panel), and GD (middle panel) on pretarget words of Experiment 1 to preview space, with pretarget word-frequency-related effects and random effects of participant and item removed. Errorbands showed 95% of confidence intervals.

3.3.2 Target region

The analysis of target region involved two covariates, preview space and preview time. Table 4 presents the results of the analysis in this region. In this region, SR preview cost was not significant, and neither were its interactions with the covariates. Semantic effect was robust for all three measures (FFD: b = 0.074, SE = 0.032, p < .05; SFD: b = 0.091, SE = 0.036, p < .05; GD: b = 0.111, SE = 0.043, p < .05). Unlike the findings in pretarget region, the direction of the effect is positive,

which indicates semantic preview benefit. This effect also interacted with preview time (FFD: b = 0.165, SE = 0.089, p < .07; SFD: b = 0.225, SE = 0.101, p < .05; GD: b = 0.236, SE = 0.104, p < .05). The three-way interaction between semantic preview benefit, preview time, and preview space reached significance for GD (b = -0.579, SE = 0.199, p < .005). Lexical effect was not significant across the duration measures, but it also interacted marginally with preview space for FFD (b = 0.097, SE = 0.050, p < .07). Skipping rate in this region showed SR preview benefit (b = 0.494, SE = 0.245, p < .05), where SR previews caused more skipping then the ID previews.

Table 5

Results of analyses on the target region in Experiment 1, with preview space (p.s.), preview time (p.t.) and the interaction (both) of the both as covariates

	FFD			SFD			GD		
	b	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
(intercept)	5.59	0.02	240.01***	5.60	0.02	224.99***	5.70	0.03	211.14***
SR - ID	0.05	0.03	1.54	0.03	0.04	0.91	0.02	0.04	0.58
UR - SR	0.07	0.03	2.33*	0.09	0.04	2.52*	0.11	0.04	2.55*
NW - UR	0.00	0.03	-0.12	0.00	0.04	0.04	0.03	0.04	0.59
prev. time	0.02	0.03	0.51	0.04	0.04	1.08	0.01	0.04	0.36
prev. space	-0.01	0.02	-0.68	-0.02	0.02	-1.18	-0.03	0.02	-1.27
p.t.:p.s.	0.04	0.06	0.77	0.05	0.07	0.75	-0.03	0.07	-0.52
SR - ID :p.t.	0.00	0.09	0.05	0.06	0.10	0.60	0.09	0.10	0.89
UR - SR :p.t.	0.17	0.09	1.86+	0.23	0.10	2.23*	0.24	0.10	2.26*
NW -UR :p.t.	0.08	0.09	0.95	0.09	0.10	0.89	0.07	0.10	0.69
SR - ID :p.s.	0.04	0.05	0.88	0.03	0.05	0.64	0.07	0.06	1.17
UR - SR :p.s.	-0.03	0.05	-0.66	-0.04	0.06	-0.65	0.00	0.06	-0.03
NW - UR :p.s.	0.10	0.05	1.95+	0.10	0.06	1.69	0.01	0.06	0.24
SR – ID :both	-0.16	0.16	-1.02	-0.16	0.17	-0.98	-0.02	0.18	-0.12
UR - SR :both	-0.27	0.17	-1.62	-0.27	0.20	-1.36	-0.58	0.20	-2.91***
NW - UR :both	0.05	0.17	0.28	0.08	0.21	0.39	0.27	0.20	1.36

3.3.2.1 Modulation of preview time and preview space

In the target analysis, preview time and preview space were put as the covariates in the statistic models of the reading times. In order to further investigate the influences by these covariates, fixation durations of each preview condition were plotted against preview space (Figure 5) and preview time (Figure 6), as in the analysis of pretarget fixation durations.

From the pattern of Figure 5, one could see that fixation durations of SR have a different pattern than those of ID and UR. For FFD, when the preview space is beyond two characters, ID and SR pattern together. As preview site getting closer to the target, pattern of fixation duration of SR splits up with that of ID, which is reflected on the interaction with positive estimation between SR preview cost and preview space.

The interaction with preview time has a simpler pattern. Regression line of each condition was grouped in two, splitting up from each other when pretarget were fixated longer. The interaction pattern showed a positive correlation of effect size of semantic preview benefit to preview time. From the pattern of semantic preview effect, one can also exclude the possibility that deficient previewing time of UR made UR and SR incomparable. Although UR does occupy a smaller portion of preview time, for the section where both UR and SR have data, their lines do split up for all three

measures, which indicates semantic preview effect within a same range of previewing time.

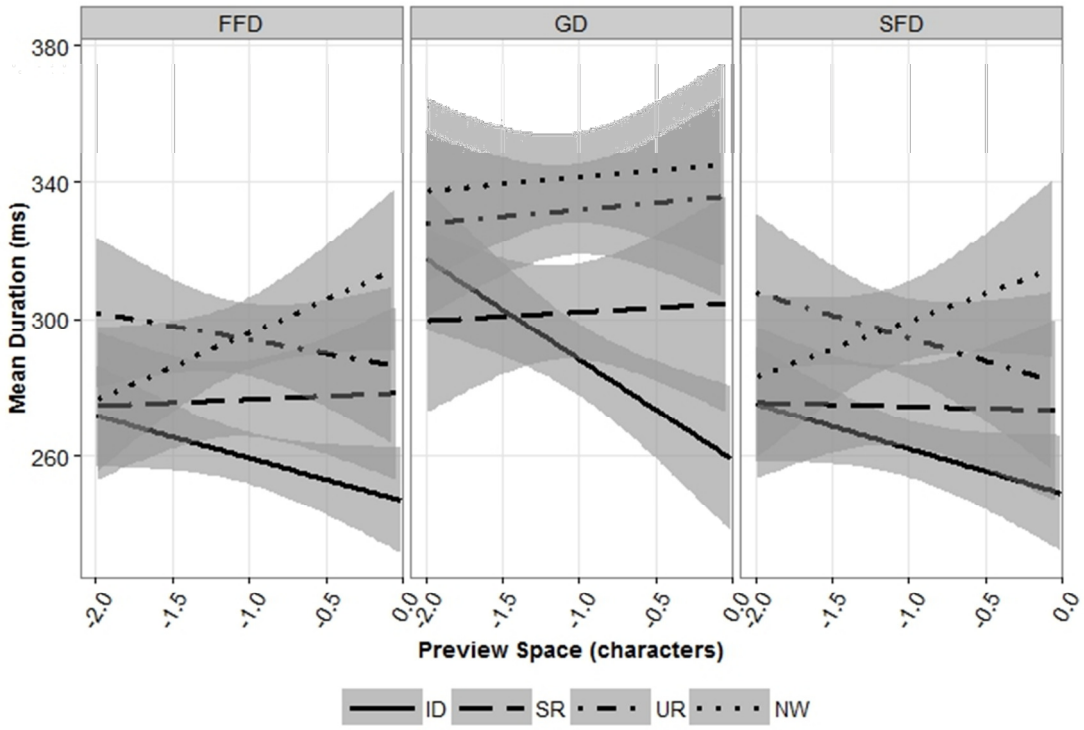


Figure 5. Estimated FFD (left panel), SFD (right panel), and GD (middle panel) on target words of Experiment 1 to preview space, with only random effects of participant and item removed. Errorbands show 95% of confidence intervals.

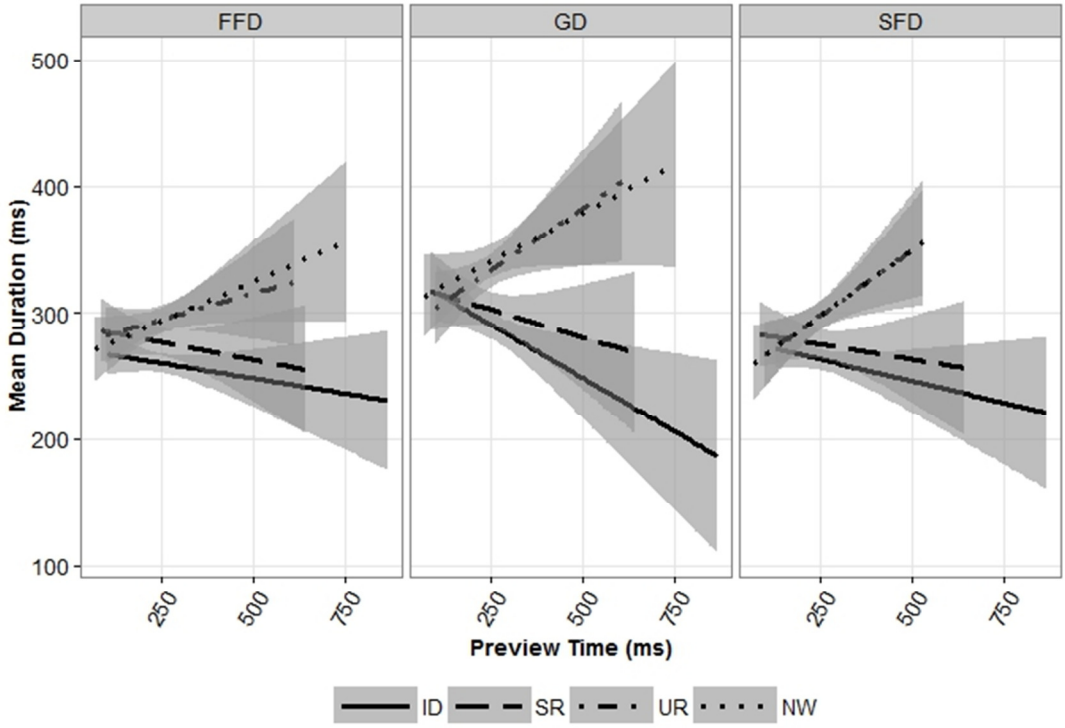


Figure 6. Estimated FFD (left panel), SFD (right panel), and GD (middle panel) on target words of Experiment 1 to preview time, with random effects of participant and item removed. Errorbands show 95% of confidence intervals.

There was also a significant three-way interaction in GD. In order to present this interaction, the data set for GD was first split by the median of preview space, and was then plotted to preview time. The reason why the data was split by preview time but not preview space is that the interaction of semantic preview benefit with preview time for GD was also significant. It would be more informative to compare how GD patterns with preview time under different preview space condition. The pattern in Figure 7 showed that the interaction pattern in Figure 6 for GD was mostly for small preview space. That is, when the eyes previewed the target from 1.05 character away from the target, longer preview time resulted in larger semantic preview benefit. And

when the preview site was within 1.05 character space, more preview time resulted in less semantic preview benefit, even though the pattern is rather obscure. While this three-way interaction for FFD and SFD was not significant, it has relatively high *t*-values for the two measures. Therefore the similar plotting scheme was applied to FFD and SFD. The three-way interaction for these two measures pattern similarly to GD, although the statistics were not significant.

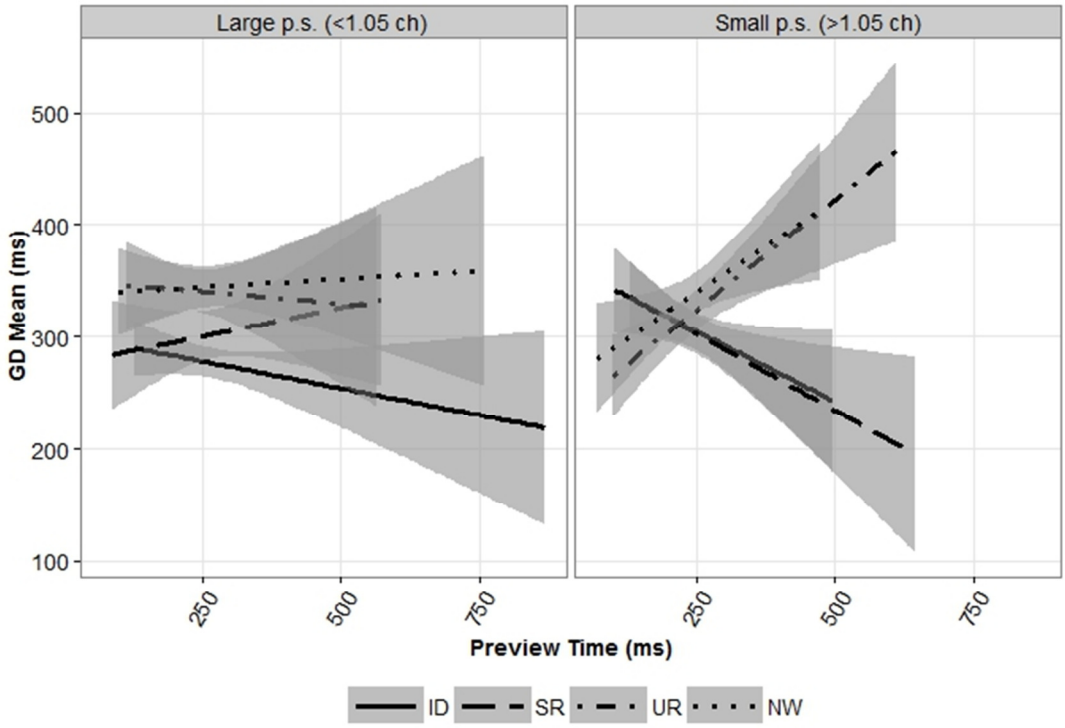


Figure 7. Estimated GD on target words of Experiment 1 to preview time under large preview space condition (within 1.05 characters, left panel) and under small preview space condition (beyond 1.05 characters, right panel) with random effects of participant and item removed. Errorbands show 95% of confidence intervals.

3.3.3 Posttarget region

For all duration measures and probability measures inspected, there were no relevant effects in posttarget region. Since the manipulation in this experiment regarded mostly about lexical processing, such late measure as spill-over was not expected. The results of the posttarget region analysis were listed below in Table 5.

Table 6

Results of analyses on the posttarget region in Experiment 1, with posttarget log word frequency (w.f.) as covariate

	FFD			SFD			GD		
	B	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
(intercept)	5.44	0.02	224.55***	5.44	0.03	212.30***	5.49	0.03	203.51***
SR - ID	-0.02	0.03	-0.50	-0.01	0.03	-0.28	-0.02	0.04	-0.55
UR - SR	0.00	0.03	-0.01	0.00	0.03	0.07	0.02	0.04	0.44
NW - UR	-0.03	0.03	-1.03	-0.03	0.03	-0.95	-0.04	0.04	-1.06
word freq.	0.00	0.01	-0.79	0.00	0.01	-0.48	-0.01	0.01	-1.21
SR - ID: w.f.	0.02	0.02	1.16	0.02	0.02	1.16	0.01	0.02	0.66
UR - SR: w.f.	-0.02	0.02	-1.15	-0.02	0.02	-1.05	-0.02	0.02	-1.07
NW – UR: w.f.	0.02	0.02	1.26	0.01	0.02	0.90	0.02	0.02	0.89

3.4 Discussion

3.4.1 Parafoveal-on-foveal effect

In this experiment, semantic preview effect was found in both pretarget region and target region. It was in expected direction in target region that having previewed a semantically related preview resulted in shorter fixation times than semantically

unrelated preview. However, in pretarget region, the effect was in the opposite direction as that in target region. There are two proposed explanations for the effect found in pretarget region. The prolonged fixation times for identical and semantic-related previews were probably due to preprocessing and integration processing of the preview when the preview seemed plausible (Kennedy & Pynte, 2005). This explanation, however, cannot reconcile with reading times of NW previews, which has no semantic information for plausibility judgment or integration process but caused numerically but not significantly longer pretarget fixation times than UR previews. UR previews were also implausible to the pre-context and imposed no processing load on integration as well. And thus according to this explanation, NW should be more similar to UR than ID or SR. The alternative involves the detection of anomaly. For the semantic unrelated preview, the sentences were implausible. When the subjects detected such anomaly, they may be predisposed to saccade earlier to the target region. This explanation may reconcile with the fact that pattern of pretarget reading times of NW was more similar to that of ID and SR. Since a NW preview had no specific word meaning, it was insufficient to conduct a plausibility judgment.

3.4.2 SR preview cost

SR preview cost was not observed in this experiment. Not only was the main

effect far from significance, but none of the interactions reached significance. This is actually in concordance with the first experiment in Yang (2013). Although plausibility for SR was not controlled in the first place, the rating results showed that inserting the SR preview to the sentence pre-context produced plausible sentence fragment. In Experiment 1 of Yang (2013), synonymous transposed words under plausible pre-context yielded no transposed preview cost. There is another factor in the design of this experiment that may cause this lack of SR preview effect. Among the materials, word frequencies of ID previews were lower than those of SR (and therefore UR) previews. Since lower word frequency may require more processing resource and therefore increase the reading time, this increment may offset the benefit brought by identical previews and consequently obscure the SR preview cost. This conjecture is further supported by the fact that skipping rate in this experiment was higher for SR than ID. Such influence of previewed word frequency on skipping rate is concordance with the results of Experiment 1 of (Yen et al., 2008).

3.4.3 Semantic preview benefit

Semantic preview main effect was significant in this experiment, along with some of the interactions. This concords with previous studies that semantic preview benefit is rather ostensive in Chinese than in some other languages (Tsai et al., 2012;

Yan et al., 2009; Yan, Risse, et al., 2012; Yang, 2013; Yang et al., 2012). The experiment here further demonstrated that semantic-related previews of two-character length without other overlapping lexical features also provide preview benefit during reading.

However, as for the interaction, previous studies and this experiment exhibits diverse patterns. In the second experiment by Yen et al. (2008), as mentioned above, they used previews with the same C1 homographic morpheme (SM), with different but homographic morpheme (DM), and unrelated controls. Although the DM previews did not show preview benefit based on the comparison with the controls, they did found preview benefit in another analysis with data split by prior reading times. In the analysis, they split the data by prior fixation duration at 220ms and tested each group of data independently. They found that, with longer prior fixation duration, reading times from DM previews resembles those from unrelated controls. Because the disambiguation of the morphemes between SM and DM previews requires accessing the whole word meaning, it indicates that longer preview time facilitates word semantic processing. This is the pattern observed in this experiment that longer preview time resulted in larger UR-SR gap.

Another study, however, showed a different picture. In the study by Yan, Risse, et al. (2012), preview space was manipulated by the position of the boundary. In their

first dataset, boundary was set right before the target word, and in the second dataset, it was set before the single-character word prior to the target. Although it is not completely parallel, the first dataset is similar to larger preview space in this experiment in contrast to the second dataset, which confined the preview space to be at least one-character away from the target, like the small preview space condition in this experiment. They found that in the first dataset, semantic preview benefit decreased when preview time increased. The reading times of semantic preview patterned like those of identical preview around one end of preview time at 150ms, but they became more alike to those of unrelated preview at the other end of 400ms. The same interaction with preview time was observed and significant for GD for the second dataset, where preview space was limited. Semantic previews resulted in shorter reading times than unrelated previews with shorter preview time but in longer reading times with longer preview time. The pattern, however, is more alike to the pattern observed under large preview space condition (see the left panel of Figure 7). That is, the pattern observed in Yan, Risse, et al. (2012) is confined only to the situation when previewing from a closer site to the target. One could attribute the discrepancy to the scopes of the effects. In their study, while the target region was also a two-character word, they manipulated the semantic relatedness of the first character. That is, they investigated the semantic preview benefit of the first constituent of

two-character words. While in this experiment, it was the two-character words themselves that were manipulated. While extracting the semantic information of the whole two-character word requires at least lexical information of both constituents, a preview of better quality may be necessary for a comparable reading pattern to single-character preview.

3.4.3.1 Plausibility effect on semantic preview benefit

Although semantic preview benefit was demonstrated in this experiment, a caveat should be noted. In this experiment, while semantic relatedness was manipulated, plausibility to the pre-context was not controlled across the materials like the sentence frames of Experiment 1 in Yang (2013). In her Experiment 2, however, when the plausibility of the sentence frames for both ST and DT previews were controlled, she found no difference between the two conditions. Although this difference was the presence of transposed preview cost in the two conditions, which could be influenced by other factors such as difference in word frequency between identical and other previews, it did point out the problem of plausibility control. Taking the effect between identical and transposed preview of DT condition in both of her experiments for example, plausible pre-context may at least diminish the gap between reading times of identical and semantic unrelated preview (in her case, to

insignificance). In addition, Yang et al. (2012) also reported plausibility effect. Reading times for *implausible & unrelated* previews were longer than the average of reading times for *plausible & unrelated* and *plausible & related* previews. This indicates that implausible pre-context may exert its own effect and lengthened the reading times for implausible previews.

Theoretically, plausibility judgment requires at least partial semantic access. The existence of plausibility effect is in fact a proof for at least partial semantic access. However, it remains questionable whether Chinese readers start integrating two-character compounds as early as during preview, without an observable interval when only the meaning of the compound was access. According to the design of Experiment 1, there is no telling whether the observed differences between SR and UR arose from difficulty in integration of the previewed words, i.e. plausibility effect, or simply from semantic accessing of the previews. The design of Experiment 2 would therefore control the sentence pre-contexts to be plausible for both SR and UR previews. There are two reasons why the plausible context was chosen instead of the implausible context. First of all, as indicated in pretarget analysis of this experiment, anomalous pre-contexts may interrupt normal reading and shortened preview time. Another reason is that in Chinese, word-level semantic preview benefit may not be observable under implausible pre-context (Yang et al., 2012). Therefore the design of

Experiment 2 would utilize plausible pre-contexts to optimize the settings for semantic preview benefit.

Chapter 4. Experiment Two: Semantic preview benefit with plausible pre-context

Experiment 2 was designed to resolve the confounding in Experiment 1. The experiment design of Experiment 2 was similar to experiment 1 except that each preview in the sentence frame was confined to plausible. Two-character words in traditional Chinese were chosen as targets and previews in the boundary-paradigm experiment. Before fixation point saccaded cross the boundary, readers might receive one of the following previews: (1) Identical preview (ID), which was the same two-character words as the target, (2) semantic-related preview (SR), which was semantically related to the target, and (3) semantic-unrelated preview (UR), which was semantically unrelated to the target. Non-word previews were excluded from Experiment 2, because a non-word preview is presumably always implausible to the sentence frame, and the control of plausibility is the issue here in Experiment 2. An item thus consisted of three kinds of previews embedded in the same sentence frame, with one of the preview being the target. The difference in eye-movement pattern between ID and SR conditions is the SR preview cost. In Experiment 1, the SR preview cost was also observed for skipping rate, but it might be the results of less control of plausibility for SR condition. According to the previous studies, where similar preview cost was minimal when SR previews were plausible to the sentence frames, SR preview cost may not be observed in this experiment. The differences

between SR and UR conditions are then semantic preview effect, which is the main concern in this experiment. The existence of semantic preview effect is then the decisive result in this experiment, where plausibility and semantic effects can be separated with reference to Experiment 1.

4.1 Method

4.1.1 Participants

Thirty students or members from National Chengchi University community (22 females, 8 males), with age ranging from 18 to 29 (M = 20.9, SD = 1.50) were recruited for the eye-tracking experiment. Participants were paid for their participation. All of them were native speakers of Taiwan variety of Mandarin Chinese, with normal or corrected-to-normal vision. None had participated in experiment one or any of the norming studies.

4.1.2 Materials

Ninety two-character compound words were chosen to be the target words, 36 of which were the same as target words in Experiment 1. Criteria for selection of target words and their respective SR previews were the same as those in experiment one. UR previews in experiment two, on the other hand, were not the same word set

as SR previews, but were selected independently in order to be semantically unrelated to the target word but to fit plausibly into the sentence frame. Again, one-thrid of the materials were verbs, and the others were nouns. Word frequencies of SR and UR words were matched, but not with that of target/identical preview. Character frequencies and stroke numbers of first and second character in each group of preview words were controlled in the same fashion (*t*s < 1.6 between SR and UR). Previews in any set shared no common characters or onset phonemes to prevent unwanted preview benefits. Table 5 summarizes the word properties of each group of previews.

Table 7

Means and standard errors of word frequency per million, C1, C2, and total strokes of the two constituents of each preview condition in Experiment 2

	Targets and ID prev.	SR previews	UR previews
Word example	清早 "early morning"	凌晨 "daybreak"	捷運 "MRT"
Word frequency	12.12 (1.27)	29.85 (1.62)	20.87 (1.75)
C1 strokes	11.31 (0.46)	12.27 (0.47)	12.19 (0.46)
C2 strokes	10.51 (0.46)	10.28 (0.50)	10.13 (0.44)
Total strokes	21.82 (0.61)	22.54 (0.65)	22.32 (0.65)

Sentence frames were constructed for each target word in a way that the sentence fragments before the target word position were plausible when followed by any one of the previews from the respective item set. The onset of target word lay from the 12th to 18th character position in the sentences. Sentence lengths ranged from 21 to 27 characters long. Other design parameters followed those of Experiment 1. An example of the experiment sentences were given below with different previews

underlined following the order of identical, semantic-related, semantic-unrelated preview:

(4) 小黃平常下班的時間都是每天清早/凌晨/捷運太陽還沒出來前。
"Huang usually gets off work at early morning/daybreak/MRT before the sun comes up."

Three experiment lists were constructed in fixed-random orders. Each list consisted of 90 experiment trials and 6 fillers distributed in 3 blocks. Each block began with their 2 fillers to bring the subject back to the experiment context after the inter-block breaks. Three conditions were equally and randomly distributed in every block. Four practice trials preceded the blocks at the beginning of the experiment to familiarize the participants with the experiment procedure.

Prior to the eye-tracking experiment, the same two norming studies were conducted as in experiment one to assess whether (1) meaning relatedness of preview to the target was as designed and (2) the combination of pre-context with preview was plausible for each item. Further, predictability of each target/preview was also assessed in order to control for predictability effect. Table 6 lists the results of each norming studies.

Table 8
Means and standard errors of rated results of the norming studies for Experiment 2

	ID	SR	UR
Meaning relatedness	-	5.57 (0.08)	1.83 (0.06)
Word Predictability	≤ 10%	< 7%	< 7%
Plausibility	5.45 (0.08)	5.47 (0.07)	5.10 (0.09)

4.1.2.1 Norming study: Meaning relatedness, sentence predictability, and sentence plausibility

The purpose of this norming study was the same as that in Experiment 1, except that in this experiment, plausibility for all three previews was expected to be high. Thirty students of National Chengchi University were recruited and paid for their participation. They were all native speakers of Taiwan variety of Mandarin Chinese. Neither did they participate in any studies of Experiment 1, nor did they participate the eye-tracking experiment.

Three fixed random lists were constructed for the study. They were composed of two sub-lists as in the norming study of Experiment 1. Sixty balanced word pairs were in each semantic-relatedness sub-list and 90 sentence trials in each sentence sub-list. The difference between this norming study and that of Experiment 1 was that in this norming study, any sentence fragment with any one of the previews was plausible, and therefore 50 fillers were inserted in each sentence sub-list. Other settings and procedures were the same as in Experiment 1.

The results showed that the meaning of SR preview was related to target/ID previews for each item, and the other way around for UR previews. Meaning relatedness for ID and SR preview was all above 3.5 (average = 5.57, SD = 0.08), while that of ID and UR preview was all below 3.5 (M = 1.83, SD = 0.06). Further,

the difference between the two groups of meaning relatedness was significant (t = 35.72, $p < .001$).

Predictability of a preview from its pre-context is presented as percentage of hit of the previews in all two-character words that the participants had written down. For all three groups of previews, each preview was written by the participants less than 10% of time. Therefore, previews used in this experiment could be regarded as unpredictable by the pre-context.

Results of plausibility of previews with pre-context showed that sentence fragments from the beginning up to the target region were plausible with either ID, SR, or UR preview taking the target region (all above 3.5; ID: M = 5.45, SD = 0.08; SR: M = 5.47, SD = 0.07; UR: M = 5.10, SD = 0.09).

4.1.3 Apparatus

The experiment setting and apparatus was identical to Experiment 1.

4.1.4 Procedure

The procedure was identical to Experiment 1.

4.2 Data analysis

Identical to Experiment 1, target region, pretarget region, and posttarget region were subject to the analyses. Also following the design of Experiment 1, first-pass duration measures and probability measures were analyzed. Eight participants observed more than 10 display changes, and so their data were excluded and were replenished with new participants. Criteria for data selection were identical to those of Experiment 1, and the resulting data loss rate was 6.2% (159) for first-pass measures and 28.4% (723), 38.8% (988), 29.2% (742) respectively for FFD, SFD, and GD. In this experiment, preview quality and previewing time span were also taken into consideration, and therefore preview space, which was implemented using launch site, preview time, which was implemented with pretarget single fixation duration, and their interaction were included as covariates in the statistic models as well. With valid preview space and preview time, 33.9% (862) of data points were retained for first-pass duration analysis for target region.

Tools of analysis and reported items were identical to Experiment 1. The difference was that according to the design of this experiment, only SR preview cost (SR–ID) and semantic preview benefit (UR–SR) would be evaluated in the models using sliding contrast.

4.3 Results

4.3.1 Pretarget region

Pretarget region is the two-character region before the target word. In addition to subject and item as crossed random effects, the analysis included preview site as covariate. Since this ROI was pretarget, preview site would be equivalent to last fixation position or launch site of the target region. Furthermore, since pretarget word frequency was not controlled at the first place, it was also taken into account as a covariate in pretarget analysis. For pretarget analysis, none of duration measures or probability measures reached significance, and so were their interaction with the covariates. The results are listed in Table 8.

Table 9

Results of analyses on the pretarget region in Experiment 2, with pretarget log word frequency (w.f.) and preview site (p.s.) as covariates

	FFD			SFD			GD		
	B	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
(intercept)	5.43	0.02	229.57***	5.43	0.02	226.46***	5.46	0.02	221.60***
SR - ID	-0.03	0.02	-1.67	-0.02	0.02	-1.28	-0.02	0.02	-1.13
UR - SR	0.01	0.02	0.35	0.01	0.02	0.43	-0.01	0.02	-0.41
word freq.	0.00	0.01	-0.56	0.00	0.01	-0.53	0.00	0.01	-0.26
prev. site	0.04	0.01	3.80***	0.04	0.01	3.36***	0.06	0.01	4.66***
SR - ID: w.f.	0.00	0.01	0.02	0.00	0.01	-0.46	-0.01	0.01	-0.61
UR - SR: w.f.	-0.01	0.01	-0.62	-0.01	0.01	-0.87	0.00	0.01	-0.29
SR - ID: p.s.	0.00	0.03	0.08	0.00	0.03	0.16	0.02	0.03	0.49
UR - SR: p.s.	-0.02	0.03	-0.84	-0.02	0.03	-0.71	-0.05	0.03	-1.64

4.3.2 Target region

The analysis of target region involved previewing space, preview time, and their interaction as covariates for duration measures and bare model without covariates for probability measures. Table 7 represents the results of target region analysis. For duration measures, main effect of SR preview cost was not significant, but it interacted with preview space for all three measures (FFD: b = 0.112, SD = 0.051, $p < .05$; SFD: b = 0.117, SD = 0.053, $p < .05$; GD: b = 0.140, SD = 0.061, $p < .05$). There were also a three-way interaction between SR preview cost, preview space, and preview time for all FFD (b = -0.002, SD = 0.001, $p < .05$) and SFD (b = -0.002, SD = 0.001, $p < .05$). Semantic preview effect had no significant main effect or any significant two-way interaction, but it also had a three-way interaction with both covariates for FFD (b = 0.002, SD = 0.001, $p < .05$) and SFD (b = 0.002, SD = 0.001, $p < .05$). As for probability measures, none of the main effects or interactions reached significance. Table 9 presents the results of the analysis.

Table 10

Results of analyses on the target region in Experiment 2, with preview time (p.t.), preview space (p.s.), and the interaction (both) of the both as covariates

	FFD			SFD			GD		
	b	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
(intercept)	5.53	0.02	233.68***	5.53	0.03	209.84***	5.62	0.03	179.01***
SR - ID	0.04	0.03	1.46	0.02	0.03	0.76	0.02	0.03	0.72
UR - SR	0.00	0.03	0.11	0.00	0.03	0.03	0.03	0.03	1.10
prev. time	0.00	0.00	0.74	0.00	0.00	0.30	0.00	0.00	-0.19
prev. space	-0.04	0.02	-1.78	-0.05	0.02	-2.26*	-0.08	0.03	-3.00***
p.s.:p.t.	0.00	0.00	-0.78	0.00	0.00	-0.52	0.00	0.00	-0.16
SR - ID :p.t.	0.00	0.00	-0.98	0.00	0.00	-1.26	0.00	0.00	-1.21
UR - SR :p.t.	0.00	0.00	0.38	0.00	0.00	-0.36	0.00	0.00	0.24
SR - ID :p.s.	0.11	0.05	2.21*	0.12	0.05	2.19*	0.14	0.06	2.28*
UR - SR :p.s.	-0.05	0.05	-0.94	-0.08	0.05	-1.50	0.03	0.06	-0.46
SR – ID :both	0.00	0.00	-2.50*	0.00	0.00	-2.27*	0.00	0.00	-1.01
UR - SR :both	0.00	0.00	2.30*	0.00	0.00	2.57*	0.00	0.00	0.61

4.3.2.1 Modulation of preview space and preview time

None of the main effects of the planned contrasts reached significance in this experiment. For SR preview cost, it only reached significance in a two-way interaction with preview space for all three duration measures, and in a three-way interaction with both preview space and preview time for FFD and SFD. For semantic preview effect, only the three-way interaction reached significance for FFD and SFD. In order to examine these interactions, reading times were likewise plotted against preview space to inspect the interaction of SR preview cost. The data of FFD and SFD were then split up and plotted as well for the three-way interaction.

The interaction between the SR preview cost and preview space is quite clear once plotted. For all three measures, the gap between the dashed line (SR) and the solid line (ID) is rather small for large preview space, but they split up when the eyes fixates near the target word during previewing. As for semantic preview effect, which is the difference between dotted dashed line (UR) and dashed line (SR), not only do the two lines entangle with each other, but their difference does not change significantly with the preview space. Although there is a pattern in SFD and FFD, where the reading times for SR is longer than those of UR when the preview site was within one character, this interaction does not reach significance, and thus one should not overemphasize this pattern.

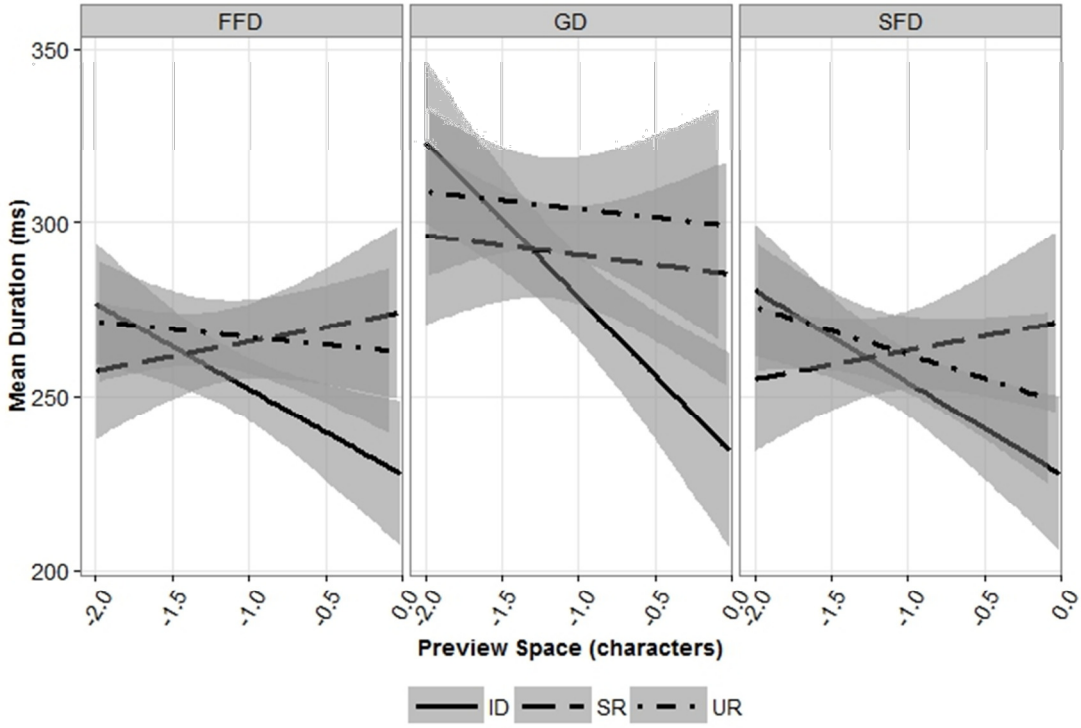


Figure 8. Estimated FFD (left panel), SFD (right panel), and GD (middle panel) on target words of Experiment 2 to preview space, with random effects of participant and item removed. Errorbands show 95% of confidence intervals.

Semantic preview effect does not reached significance in any two-way interaction but only in the three-way interaction. It is therefore disputable which covariate should be split up in two groups and which should be plotted as a continuous variable. Here, in order to compare the results with Experiment 1 and with previous studies, preview time was again plotted as the continuous variable, while the datasets of FFD and SFD was split by the median of preview space. The three-way interaction would be the difference in their pattern between the two groups. Figure 9 and Figure 10 are the split plots for FFD and SFD, respectively.

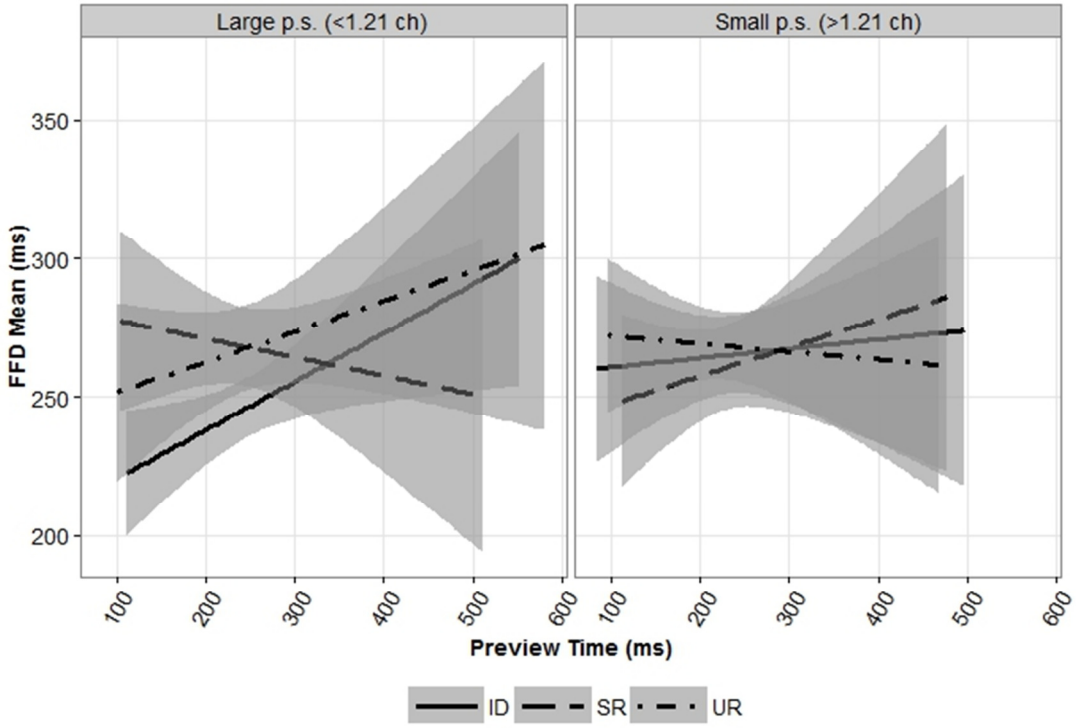


Figure 9. Estimated FFD on target words of Experiment 2 to preview time under large preview space condition (within 1.21 characters, left panel) and under small preview space condition (beyond 1.21 characters, right panel), with random effects of participant and item removed. Errorbands show 95% of confidence intervals.

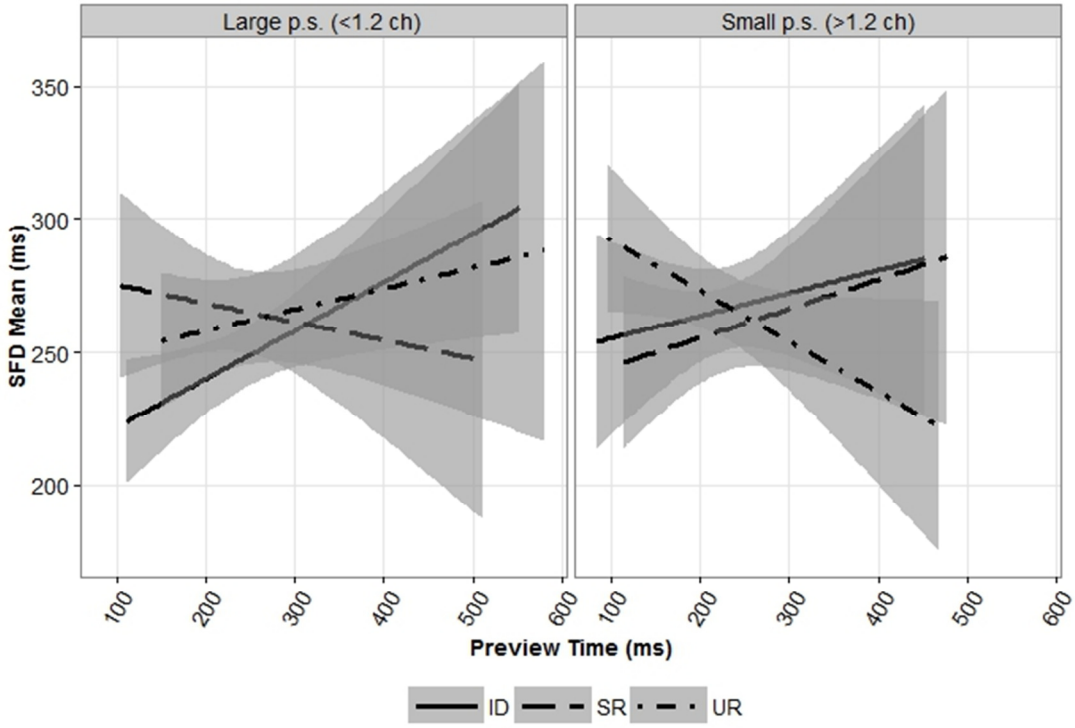


Figure 10. Estimated SFD on target words of Experiment 2 to preview time under large preview space condition (within 1.2 characters, left panel) and under small preview space condition (beyond 1.2 characters, right panel), with random effects of participant and item removed. Errorbands show 95% of confidence intervals.

The interaction patterns show that with large preview space, which is within 1.21 character space for FFD and 1.2 character space for SFD, semantic preview benefit increases with preview time. And when previewing from a farther site, the lines for SR and UR mostly tangle up in FFD, and there is a trend for SR previews to have longer target SFD than UR previews with longer preview time.

4.3.3 Posttarget region

Posttarget analysis included posttarget word frequency due to the same reason

as in pretarget analysis, but did not include preview time or preview space. In this analysis, none of the main effects reached significance nor did they interact with the covariate (Table 10).

Table 11

Results of analyses on the posttarget region in Experiment 2, with posttarget log word frequency (w.f.) as covariate

	FFD			SFD			GD		
	B	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
(intercept)	5.48	0.02	253.47***	5.47	0.02	257.48***	5.52	0.02	235.33***
SR - ID	0.00	0.02	0.22	0.00	0.02	0.04	-0.01	0.02	-0.40
UR - SR	0.02	0.02	0.87	0.02	0.02	0.98	0.02	0.02	1.10
word freq.	-0.01	0.01	-2.04*	-0.01	0.01	-2.14*	-0.02	0.01	-2.86**
SR - ID: w.f.	0.02	0.01	1.61	0.02	0.01	1.68	0.02	0.01	1.30
UR - SR: w.f.	0.00	0.01	-0.35	-0.01	0.01	-0.51	0.00	0.01	0.22

4.4 Discussion

In Experiment 2, the main effect of semantic preview effect observed in Experiment 1 was absent. Only the three-way interaction between semantic preview effect and the interaction of the two covariates reach significance for FFD and SFD, while such interaction was significant only for GD in Experiment 1. As for SR preview cost, while it was totally absent for main effect, it was positively interacted with preview space, and the three-way interaction was also significant. In non-target region, shortened pretarget reading times for UR condition in Experiment 1 were not observed in this experiment.

4.4.1 Parafoveal-on-foveal effect

The absence of pretarget semantic preview effect was expected. In Experiment 1, the proposed explanation was the observation of anomaly during preview. In the design of Experiment 2, such anomaly was eliminated by plausible combination of previews and sentence pre-contexts. Therefore, the result of Experiment 2 in pretarget region further vindicated the hypothesis proposed in Experiment 1.

4.4.2 Semantic preview benefit

The lack of semantic preview main effect is consistent with the conclusion of Yang (2013) that for two-character words, only plausibility effect can be detected. But this is in contrast with the results of Yang et al. (2012) that semantic preview benefit can be observed only under plausible pre-contexts but not under implausible ones. The difference may be due to the discrepancy is experiment design. The target words and previews in their study were single-character words. In order to further investigate this issue, the patterns of how semantic preview effect interacts with preview time and preview space in this experiment and in previous studies should be compared. Although semantic preview main effect was not significant in Experiment 2, the difference between the patterns of its interaction with preview time is greater under different preview space conditions. When previewing at a site near the target

word, preview benefit for FFD and SFD was increasing with preview time. This is similar to what was observed in Yen et al. (2008) that longer preview time helped to disambiguate the different homographic morphemes. On the other hand, when preview site was about 1.2 characters and beyond, the pattern reversed. Small preview space in this experiment lead to a pattern in SFD that semantic preview benefit decreased and eventually became cost with increasing preview time. This pattern then is similar to the ones discovered in Yan, Risse, et al. (2012), even though their targets and previews were the first constituent characters of two-character words. As mentioned in the discussion of Experiment 1, their studies found that semantic preview benefit decreased, and became cost when previewing from beyond one-character range (their dataset 2), which is consistent to the pattern here.

Following the explanation in Experiment 1 that previewing from a closer site results in a similar pattern in the experiment with single-character previews (Yan, Risse, et al., 2012), it could therefore be due to the similar reason, that plausible contexts also ease the process and result in the similar reading pattern, even when the previewing site is far from the target. However, it does not reconcile with the fact that when previewing from a closer site, the trend for semantic preview benefit reverses again, and increases with preview time. For UR previews in both experiments, this should be the optimal preview condition, with plausible pre-context and large preview

space. To be consistent with previous explanation, the integrated partial sentential meanings may be the cause here. While better preview is available, previewing the target may have resulted in integration of the sentence meaning. Amending the sentence meaning may again depend on how close the previewed meaning is related to the true meaning. This hypothesis requires experiments investigating into, for example, different possible integration processes to verify.

4.4.3 SR preview cost

In contrast to Experiment 1, SR preview cost interacted with the covariates in this experiment, although the main effect remained insignificant. Following the discussion in Experiment 1, the lack of SR preview cost is in concordance to Yang (2013). And since the word frequencies of ID previews/targets were lower than those of SR and UR previews as in Experiment 1, the same reason of lack of SR preview cost main effect as in Experiment 1 could apply here. While SR preview cost was not the core issue in this study, the interaction pattern may need further studies with finer control to resolve.

Chapter 5. General Discussion

In this study, two boundary-paradigm experiments were conducted to investigate semantic preview benefit of Chinese two-character compound words. In Experiment 1, there were identical, semantic-related, semantic-unrelated, and non-word previews for each target word embedded in the sentence frame which was plausible for identical and semantic-related previews, but not for the rest of the two. Experiment 2 applied the same design, but non-word previews were excluded and the sentence frames were plausible for all three of the previews. In Experiment 1, the comparison between UR and SR thus comprised the effect of meaning relatedness to the target and previews' difference in plausibility to the sentence pre-context, while that effect in Experiment 2 could be said to be irrelevant to plausibility difference.

5.1 Parafoveal-on-foveal effect

The core issue of the study is semantic preview benefit. In Experiment 1, the effect was found as early as pretarget first-pass duration measures, but in the reverse direction that readers spent less time on pretarget region when previewing UR preview. Such an early effect was not found in Experiment 2. When the eyes fixate on the pretarget region, the word at the target region was still preview, and so this effect is related to the interaction between the preview word and the pretarget word. In this

study, the effect was attributed to the relation between the pre-context and the preview. The shortened pretarget reading times were due to the situation where the readers detected an anomaly when previewing the implausible UR preview during reading, and hence made a premature saccade to the place of the anomaly, namely the target region. This is supported by two other observed phenomena. First, only UR previews but not NW previews along that caused this shortened fixation times. Since NW previews had no real meanings to incur anomalous situations. Secondly, with plausibility control in Experiment 2, such effect disappeared. This suggests that implausibility in Experiment 1 was indeed the source of the POF. However, such explanation was inconsistent with previous studies. The studies with word previews, single-character or two-character, reported null POFs (Yang, 2013; Yang et al., 2012), while among studies investigating preview benefit from the first constituent character of two-character words, Yan et al. (2009) reported POF from semantic related previews. But in Yan et al. (2009), previewing a semantic related preview resulted in shorter pretarget GD, significantly shorter than the unrelated and phonological previews. This is again in contrast with current findings.

The findings in Yan et al. (2009) can be attributed to the fact that the preview words were actually all nonwords except for the identical previews. Therefore the comparison between the semantic and unrelated previews did not involve the

difference in whether an anomaly was detected. Without a whole-word meaning, the result may only reflect the lexical processing of individual characters but not a primary comparison for anomalism. But this explanation is not adequate for the other two studies that reported null POFs, since the materials in their studies were independent words. Since judgment for anomalism may involve various factors such as syntax, semantics, transitional probability, contextual constraints, or strength of the effect from the previous factors, there may have been different factors at work that resulted in the diverse results. Taking the example sentence with control preview for DT from the first experiment in Yang (2013) for instance: 叔叔書房裡掛的船票是一件珍貴的文物。"The boat ticket hanging in uncle's study is a precious relic." The sentence fragment up to the target region is not as bad to be an anomalous sentence fragment after all. Further studies may therefore be necessary to address this issue of anomaly detection.

5.2 Semantic preview benefit

The two experiments demonstrated that semantic information of a parafoveal two-character words can be accessed, and such effect can be modulated by plausibility of the preview in the pre-context. The difference in plausibility resulted in the main effect between the SR and UR previews, which then disappeared when plausibility

was controlled in Experiment 2. Such a pattern seems compatible with the conclusion made by Yang (2013). However, her conclusion was based on the presence of transposed preview cost based on different transposed previews. Although the word frequency of identical preview words in this study was not well controlled to match the other previews, the same statistic models were built with another set of planned contrast for a fair comparison between SR/UR preview cost and transposed preview cost in the two studies. The following table shows the pattern of these preview costs in this study:

Table 12

Main effects of non-identical preview costs from both experiments

	FFD			SFD			GD		
	b	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
Experiment 1									
SR - ID	0.05	0.03	1.54	0.03	0.04	0.91	0.02	0.04	0.58
UR - ID	0.12	0.03	3.81***	0.13	0.04	3.44***	0.14	0.04	3.11***
Experiment 2									
SR - ID	0.04	0.03	1.46	0.02	0.03	0.76	0.02	0.03	0.72
UR - ID	0.04	0.02	1.64	0.02	0.03	0.81	0.06	0.03	1.90+

Intercepts and interactions with the same set of covariates as LMMs for target region above were omitted.

The pattern of the main effects is consistent with those from Yang (2013). In this study, semantic preview also manifested itself in the interactions with covariates for preview time and preview space in Experiment 1, and only so in Experiment 2. Therefore, one could make the conjecture that the semantic preview effect may still

have existed in Yang (2013), but such effect was too elusive that it was not observable without analysis with preview time and preview space.

5.2.1 Modulation of preview time and preview space

Previous discussion has compared the results of each experiment with previous study analyzing preview effects with preview time and preview space. Logically, there were three types of interaction with preview time. Firstly, preview benefit, i.e. the difference in reading times between the unrelated previews and the semantically related previews, decreases with preview time. This is observed in Yan, Risse, et al. (2012). On the contrary, preview benefit may increases with preview time. Though not directly, Experiment 2 in Yen et al. (2008) indicated that readers could access the right morphemic meaning, which depended on the whole word process in their design, only with longer preview time. Secondly, the benefit may largely remain the same across different preview time. With three-way interactions found in both experiments, different patterns of interaction with preview time were also found for different preview space, as listed in the following table.

Table 13

Trends of interaction between semantic preview effects and preview time under different preview space conditions in the two experiments

	Large preview space (previewing site near the target)	Small preview space (previewing site away from the target)
Experiment 1	Decreasing (FFD, GD)	Increasing (SFD, FFD, GD)
Experiment 2	Increasing (SFD, FFD)	Decreasing (SFD)

In large preview space condition in Experiment 1 and small preview space condition in Experiment 2, the effect decreases with preview time, like the observation in Yan, Risse, et al. (2012). Their proposal for this phenomenon is that with longer preview time, accumulation of lexical information from the parafoveal preview may eventually come to the point where difference between the semantically related preview and the target becomes too significant to cause any benefit. This can also explain the disappearance of DM preview benefit in Yen et al. (2008), where long preview time allowed the readers to distinguish the difference between two homographic morphemes.

The two increasing patterns should be discussed separately. The reason for this is that they were under extremely different preview conditions. The pattern found in Experiment 1 was the preview benefit when the readers previewed from about one-character away, with UR previews being implausible to the pre-context. SR previews, on the other hand, were previewed under the same condition in Experiment 2, which means that the accumulation of lexical information up to a too-much level

should also be there in Experiment 1. The fact that semantic preview benefit still increased under this circumstance indicates that implausibility may have blocked further semantic access for the UR previews, which not only lead to null lexical effect but also the premature saccade conjectured above for pretarget semantic preview effect.

The increasing pattern in Experiment 2 should have another underlying mechanism, since preview time and preview space were very different that of the increasing pattern in Experiment 1. Activation of lexical meaning would not be the cause here, because from previous discussion, it has been conjectured that semantic activation could reach the level that cancels semantic preview benefit under worse preview condition, such as farther preview site or implausible UR. Therefore, one could resort to integrated meaning, as logically the next step after semantic activation. The level of difference between meanings of sentence fragments with the preview and with target should be different for SR and UR. While this was not tested in this study, it could be the reason why under optimal preview condition, SR previews became again better previews than the UR ones.

5.2.2 Implication to reading models and contextual processing in reading

In this study, the existence of semantic preview effect, though minimal, seems

to further support the theoretical architecture of attentional gradient models and against attention shift models. The mechanism proposed in E-Z Reader incline to prohibit words that have been identified in L1 stage to be the target of saccade programming, while semantic activation is performed during L2, which starts after the completion of L1. Although in SWIFT, activation level of a word decreases during the second stage of lexical processing (lexical completion stage), which gradually lowers the probability of the word to be the next target, the stochastic target selection process could still select such a word as target. Therefore, following the architecture of SWIFT model and the finding in this study, one could conjecture that during reading, words within a window around the fixation are activated in parallel, though not homogeneously. Such lexical activation could reached the level at which semantic information is activated.

However, one caveat should be noted: The discrepancy of reading behaviors between the two experiments indicates plausibility effect at work, which implies higher level processing. While most of the models include no mechanism for how higher level processing could influence eye movement patterns (Reichle, Warren, et al., 2009), E-Z Reader 10 (Reichle, Warren, et al., 2009) does consider how such processing may influence eye movements. However, it is an integration stage following the completion of L2 and it induces regressive saccades or prohibits current

saccade programing to the next word when the integration process fails. Since it is so late a process, the previewed plausibility effect observed in this and previous studies may not be attributed to this process. Another possible theoretical explanation for this contextual factor is predictability, which is included in both SAS and GAG models. In E-Z Reader, predictability of the up-coming word determines whether the word should be skipped or modulates the time of both L1 and L2 processing. In SWIFT, predictability modulates the rate of the lexical completion stage. In Experiment 1, predictability was controlled to be 0% and in Experiment 2, it was controlled to be under 10%. With this design, the effect induced by predictability, as assumed in these models, should not confound the effects observed in Experiment 1&2.

However, as has pointed out in Schotter et al. (2015), contextual constraint is a contextual properties that is related to but not equal to predictability. While predictability means how a certain word form is predictable from the context, contextual constraint defines a range and a genre of concepts that is determined by the pre-context. While such constraints in the two experiments varies in a relatively large range, semantic genre of these constraints were not inspected. The following section will discuss the possibility of intervention from such contextual constraints.

5.2.3 Contextual constraint as an alternative to plausibility effect

As has been demonstrated in some ERP studies, maybe contextual constraint, rather than predictability of a certain word form, is the key factor in lexical activation during reading (Kutas & Hillyard, 1984; Metusalem, Kutas, Hare, McRae, & Elman, 2012). Although eye-movement models usually utilize predictability as the contextual factor, there have been eye movement studies that showed the influence of contextual constraint.

Schotter et al. (2015) demonstrated that contextual support is necessary for semantic-related non-synonyms in English to exhibit preview benefit. In their first experiment, sentences were designed to moderately constrain toward the targets (average 21%, and 75% when the responses belonging to the general idea of the target were also counted), and semantic preview benefit was observed. The comparison conducted in their second experiment along with the previous results from Schotter (2013) showed that such a contextual support is necessary for general semantic preview benefit in English. The rationale under the phenomenon is that constraining sentences activate not a single word form but a group of related concepts, or a range of ideas that could manifests itself in various word forms. When an expectation has been made about the range of the up-coming words, the parafoveal word should be easier to identify than under neutral pre-context.

In the current study, sentence contexts were all controlled not to be predictable to any preview. While sentence pre-contexts have different degrees of constraint (10%–75% in Experiment 1; 6.7%–56.7% in Experiment 2), targets and previews were written by rating participants less than 10% of the time. In Schotter et al. (2015), however, they counted the constraint to the target via combining responses belonging to the genre as the target. According to this calculation, there might be such difference in constraints in the material. Take the following experiment sentence from Experiment 2 for example:

(5) 期中考的內容要求考生閱讀合同內容並分析其利弊優缺。

While the target 合同 "contract" and the corresponding UR preview 剪報 "newspaper clip" never appeared in participants' answers, UR-related items have been massively answered, including words such as 文獻, 文章, 散文, 篇章, 資料, 報紙, 文本, 論文. They sum up to a 50% constraint in the rating. While this pre-context biases toward the UR preview, others may bias toward either the UR preview or the ID/SR preview. Although plausibility control in Experiment 2 was not consistent to the contextual constraint control when calculated in the way proposed by Schotter et al. (2015), according to their account, biasing toward a certain genre of idea would help accessing semantic information parafoveally the specific word form belonging to that genre. In the case of Experiment 2, this could lead to over-activation of UR

preview when the context was biased toward it. It would then lead to greater cost when the unexpected target was foveally read. Such an account, needs more research as well in order to further test this possibility and to determine whether such an account is plausible for Chinese two-character words.

5.3 SR preview cost

Previous studies in Chinese preview benefit have demonstrated phonological and orthographic preview benefits. In this study, however, such effect is rather elusive in that in both experiments, while among previous studies, the presence of non-identical preview cost was diverse. The diversity could be due to the difference in materials or the definition of such effect. For example in Yang et al. (2012), the identical effect that reached significance was the comparison of reading times of identical condition to the average of the other three condition. As for Yang (2013), there was no non-identical preview cost as well in the second experiment. In another experiment (Experiment 1, Yen et al., 2008) investigating preview benefit of two-character compounds, identical preview benefit was found between unrelated previews (e.g. 抗原 "antigen") and identical previews (e.g. 侍從 "aide") for FFD and GD. The design was more similar to that of Experiment 1 in that their unrelated previews were less plausible than identical previews in the sentence frames ($p < .001$).

Additional analyses were than conducted in both experiments for a fair comparison with previous studies. Alongside with the contrast discussed in 5.2, planned contrasts that tested reading times between average of non-identical previews and identical previews were also applied in LMMs. The following table integrates the non-identical-to-identical effects from different experiments discussed above for comparison.

Table 14

Selected results of non-identical-to-identical effect from various studies that match in their designs as close to those in current study

Experiment	**Unit**	**Contrast to identical condition**	**Main effect**
Yang et al. (2012)			
Experiment 1	1-char. word	Related-implausible and unrelated-implausible	Yes
Experiment 2	1-char. word	Related-plausible, unrelated-plausible, and unrelated-implausible	Yes
Yen et al. (2008)			
Experiment 1	2-char. word	Unrelated-implausible	Yes
Yang (2013)			
Experiment 1	2-char. word	Related-plausible	No
Experiment 2	2-char. word	Unrelated-plausible	No
This study			
Experiment 1	2-char. word	Unrelated-implausible	Yes
Experiment 1	2-char. word	Related-plausible	No
Experiment 1	2-char. word	Unrelated-implausible and related-plausible	Yes
Experiment 2	2-char. word	Related-plausible	No
Experiment 2	2-char. word	Unrelated-plausible	No
Experiment 2	2-char. word	Related-plausible and unrelated-plausible	No

From the comparison above, it seems that even non-identical preview effect requires some plausibility contrast between the identical previews and the

non-identical, semantically related previews in order to be significant. Such interpretation should remain undetermined at this point, since for those experiments that showed no non-identical preview cost, the identical previews themselves were not well controlled, as stated in Yang (2013) and as presented in both experiments in previous chapters. In this study, as mentioned in Experiment 1, SR preview cost may have been blurred by the lower word frequency of the targets and identical previews.

5.4 Limitations and suggestion for future studies

This study aims to demonstrate semantic preview benefit for Chinese two-character compounds. Experiment 1 demonstrated that semantic information can be accessed from two-character compounds parafoveally, while Experiment 2 further confirmed that while much of the difference between SR and UR conditions were due to intervention from implausible pre-context, semantic relatedness was still reflected in the interaction between reading times, preview time, and preview space. However, the intervention from plausibility was only conjectured from the data at hand, and there could be other mechanisms at work for the plausibility control in the experiments. For example the account of contextual constraint proposed by Schotter et al. (2015) could have been a factor in Experiment 1 that lengthened the target reading times for UR conditions. While in this study, rated plausibility was the only

reference for the control, further studies or analyses are needed in order to address this issue of integration process.

Another issue related to this study is the internal structure of Chinese compounds. While this study has focused on generalizing the results by Yang (2013) to general two-character compounds in Chinese, there are still other types of two-character words such as monomorphemic word or, as have been argued by some linguists to be words, combination of single-character adjective-noun pair (e.g. 紅花). It has been demonstrated that processing of these two-character words can be influenced by the closeness of the constituents (Cui, Drieghe, et al., 2013). Other intra-word relation between constituent characters in two-character compounds also varies to some extent. For example, inherent syntactic structure between the two characters, such as verb-object (e.g. 跳舞) or modifier-noun (e.g. 汽車), or transparency, which was briefly discussed in Introduction, may all influence the process of semantic activation and meaning integration. The modulation of preview benefit by foveal load could also play a role here. It has been demonstrated that foveal load may limit the cognitive sources available for parafoveal processing (Tsai et al., 2012; Yan, Kliegl, Shu, Pan, & Zhou, 2010). The interaction between cognitive load required by the first constituent and the intra-word relation could incur different process in semantic activation of the word, and in turn result in various possibilities

regarding semantic preview. While this study showed that meaning of general two-character compounds can be access during preview, detailed mechanisms and nuance differences underlying these results require more research to answer.

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Appendices

A. Materials of Experiment 1

Sentence frame	ID	SR	UR	NW
考試還沒結束，小姿已經在計畫**暑期**出遊的地點和行程。	暑期	夏天	洗澡	脫凍
為了吸引各路高手，這次圍棋比賽**贏家**獎金總共有十多萬元。	贏家	冠軍	沙漠	規請
這位畫家死後，人們才發現他許多**不朽**鉅作藏在地下室裡。	不朽	偉大	港口	儒次
為了公司的利益，公司高層**杜絕**所有對外的研究成果發表。	杜絕	禁止	草案	遊梁
小朋在高中同學的婚禮上負責**收受**賓客送的禮物並一一記錄。	收受	納入	鐵路	讀保
小葵在正職之外，也兼差做兒童**繪本**創作的工作。	繪本	圖書	溪流	圍現
貝貝從前每個禮拜都會固定**投稿**社論，為的是持續鍛鍊文筆。	投稿	筆者	壯觀	錫個
考上相關科系後，表姊開始關心**時尚**消息以避免資訊過時。	時尚	潮流	素質	考還
經歷多年獨裁，當地居民開始尋求**武裝**勢力協助脫離暴政。	武裝	暴力	郵件	似定
根據風水師的建議，要在別墅**玄關**放置盆栽以阻擋煞氣。	玄關	門口	圖書	年鉅
一直住鄉下，老李從沒有利用**電車**旅行或是通勤的經驗。	電車	鐵路	牆壁	續哥
環保署懷疑這次如此嚴重的汙染**源頭**可能不只一個。	源頭	祖先	魔術	農降
小黃平常下班的時間都是每天**清早**太陽還沒出來之前。	清早	凌晨	豬肉	居備
全國人民都在電視機前觀賞這場世紀**王室**婚禮的現場轉播。	王室	貴族	木材	者佳
傳統造型的花燈上頭有許多**謎語**提供大家腦力激盪的機會。	謎語	題目	寒假	高旅
梁博士的專長是研究宋朝時期**龍袍**圖樣的設計及圖案的意義。	龍袍	皇帝	冰箱	師發
遊手好閒的舅舅終於開始體會**光陰**寶貴逝者難尋的道理。	光陰	歲月	坦承	威管
小芸把家當都搬到新家，決意**斷絕**過去的人際關係專心創作。	斷絕	脫離	禮物	要宇
這次招標過程中，安和企業受到**仇家**抹黑，喪失參與的權利。	仇家	敵人	鳥類	後抗
脫下警察制服之後，阿輝選擇一個**安逸**舒適的退休生活	安逸	舒服	廟宇	消面
這次大會預計邀請兩位知名**文豪**演講，鼓勵後進從事創作。	文豪	詩人	頻繁	係周
這次的舞台兩側規畫作為**道具**放置的空間，禁止他人進入。	道具	器材	臉色	長受
小儒徹夜沒睡覺，為大家製作**標語**準備明天的抗議行動。	標語	口號	截止	掃知
離家十年後返鄉，小冬發現**兒時**故鄉的樣貌已經難以辨認。	兒時	童年	蒸汽	被都
繼承了鉅額遺產的兒子開始**奢侈**度日，終於耗盡所有家產。	奢侈	豪華	器材	福新
這次周年慶的活動中百貨公司**贈品**品質都非常好，很吸引人。	贈品	禮物	耳朵	排波
探險隊隊長最後決定把前方**綠洲**當作下一階段的探險目標。	綠洲	沙漠	貨幣	司歐
巷口新開的酒吧裡聚集了許多**艦長**談論著第一次出海的經驗。	艦長	船員	隱藏	員是
魏老師提到，在森林比較**幽暗**或是潮濕的地方容易生長蕈類。	幽暗	陰影	榮譽	個安
古人相信如果違背神，天神將會**屢次**降下災難荼毒一切生靈。	屢次	擺脫	暴力	業在
剛回家的哥哥認真的講述上週街頭**慘案**調查過程的點點滴滴。	慘案	頻繁	乾淨	拜菜
最近新開幕的溫泉旅館，裡面所有**沐浴**設備都是設計訂做的。	沐浴	洗澡	旋律	迎質

(Continued on next page)

Sentence frame	ID	SR	UR	NW
參加服務隊的小東每週固定**探視**獨居長者和行動不便者。	探視	拜訪	步驟	棟很
欣欣企業內部的管理階層**名聲**一向不佳，很難留住新人。	名聲	榮譽	炸彈	律延
底格里斯河在科威特的出海口附近**污泥**嚴重堆積影響觀瞻。	污泥	廢水	拜訪	社室
負責打掃的阿伯常常發現同學**證件**遺落在自習室的桌上。	證件	護照	稀有	富隊
世人不知道，其實邪惡巫師**本性**善良，可惜後來自甘墮落。	本性	素質	濕地	感擅
健康檢查的報告指出小哲可能**聽力**方面的問題又惡化了。	聽力	耳朵	拋棄	業絲
葉教授的實驗室研究病毒**潛伏**機制的秘密，累積了許多資料。	潛伏	隱藏	冠軍	冒沐
自古以來這個地區就有眾多**城邦**各自管理自己的領土。	城邦	王國	題目	堯雇
學校的老師安排讓學生觀看**屠宰**豬隻的影片進行生命教育。	屠宰	殺死	匯率	年無
為了進行新一波的宣傳活動，店長**雇用**額外的員工扮吉祥物。	雇用	聘請	口號	自痕
報紙大篇幅報導了這位通緝要犯**自首**投案的消息。	自首	坦承	王國	牧塞
學校為了鼓勵大學生去感受**鄉里**生活的面貌而開辦體驗營。	鄉里	田野	殺死	原彥
這次歐洲之行的主題是歐洲各地**宏偉**莊嚴的建築及周邊景點。	宏偉	壯觀	擺脫	東裡
莊博士的論文發現桑族人的傳統**曲調**地區差異非常大。	曲調	旋律	童年	居實
附近居民謠傳這片森林深處**毒氣**瀰漫，一般人無法隨意通過。	毒氣	瓦斯	士兵	會物
偵辦案件時，警察會從嫌犯**面部**微妙的變化來捕捉情報。	面部	臉色	詩人	產即
隔壁老太太的閣樓放滿了大量**鈔票**零錢，都是她的長年累積。	鈔票	貨幣	敵人	記搭
雖然要價很高，這一棟套房**隔板**材料及施工品質都很差。	隔板	牆壁	漏洞	集媽
阿東研究所有方案的潛在**缺陷**還有可能的改進方案。	缺陷	毛病	凌晨	燙能
這裡的員工很多都是職業**軍官**退休，想要開創第二春的人。	軍官	士兵	聘請	商維
這間小酒吧名聞遐邇，是往來**旅人**一定會去休息小酌的場所。	旅人	乘客	舒服	增乾
哥哥遠從屏東來到嘉義拜訪這位**高人**尋求指點迷津。	高人	禪師	洪水	營報
在新幾內亞的叢林裡，蔡教授發現許多**罕見**物種的棲息地	罕見	稀有	門口	凍滿
根據新市鎮的藍圖，原本**海灣**週邊的管制區將規劃為公園。	海灣	港口	揚言	塔宣
日本來的專家依據本地區**河水**分布的情形規畫新的灌溉系統。	河水	溪流	悲劇	般樺
記得提醒新來的看護，姑媽**年歲**已經不小了，要特別小心。	年歲	壽命	牽涉	廷遇
檢方最後深入調查，發現案情**波及**許多政商界的大人物。	波及	牽涉	歲月	許處
小洵依照規定把剛送來的產品**冷藏**保存以維持產品新鮮。	冷藏	冰箱	乘客	舞典
每年編輯委員都會新增一些**詞目**解釋，讓這本百科跟上時代。	詞目	字典	夏天	來訴
小陶發現昨天買的餅乾已經**到期**非常久了，趕緊找店家退貨。	到期	截止	財務	提仗
八卦報紙報導議員房間的所有**寶物**幾乎都是來自貪汙的款項。	寶物	鑽石	祖先	雅屏
體驗營的晚餐是當地居民的特製**香腸**搭配現採的野菜。	香腸	豬肉	宮殿	園細
這支記錄片是為了詳實記錄**瀉湖**生態裡的點點滴滴。	瀉湖	濕地	字典	置弟
爸爸因為工作的關係，常要處理**沸騰**滾燙的熱水，十分危險。	沸騰	蒸汽	貴族	萊聞
歷史博物館最新的展覽展出許多**雕塑**描繪佛陀時期的生活。	雕塑	銅像	奇怪	理除
在舞台上，帶領抗議民眾的領袖**宣示**抗爭的目的和決心。	宣示	揚言	潮流	思棗

(Continued on next page)

Sentence frame	ID	SR	UR	NW
慶典的結尾是由眾人一起**丟掉**裝扮衣物，象徵回到日常生活。	丟掉	拋棄	禪師	套咳
一大早工人們就準備了很多**爆破**工具準備進行拆除作業。	爆破	炸彈	納入	會剛
每年特定時節皇帝都要前往**祭壇**舉行祭拜祖先和上天的典禮。	祭壇	廟宇	瓦斯	能岳
家隆一直無法休息，因為部門的系統**缺陷**已經危及公司運作。	缺陷	漏洞	筆者	閣片

B. Materials of Experiment 2

Sentence frame	ID	SR	UR
這次財務報告尚未計入子公司**虧本**造成的打擊與影響。	虧本	損失	拓展
期中考的內容要求考生閱讀**合同**內容並分析其利弊優缺。	合同	契約	剪報
主修油畫的介良騎腳踏車到各地鄉鎮**宣導**美感教育的重要。	宣導	呼籲	瀏覽
新上任的校長昨天表示，她對於學校**收支**狀況感到擔憂。	收支	財務	班級
導遊特別提醒團員有關森林的數個危險**棧道**分布的位置。	棧道	路線	跡象
為了吸引各路高手，這次圍棋比賽**贏家**獎金總共有十多萬元。	贏家	冠軍	賽程
生病的王老伯伯喜歡找不同**看護**聊天，排解住院的無趣。	看護	患者	嗜好
再三個月後，阿仁就要正式**報到**成為國軍志願役的一份子。	報到	登記	僱用
遊人來到此處山間多半是為了感受**壯麗**山景帶來的感動。	壯麗	偉大	乾淨
在所有的動物中小婷最喜歡**老鷹**以及其他類似的大型猛禽。	老鷹	鳥類	狐狸
來登記的民眾都急著想知道目前**順位**先後及公佈中獎的時間。	順位	排名	黨部
驚慌的姑姑希望大家幫忙**搜索**遺失的中獎彩卷。	搜索	查詢	阻止
大家常常形容振陽是一個令人**開心**但是難以捉摸的傢伙。	開心	愉快	害怕
到市政府辦公的鍾太太一直**詢問**有關兒子遷戶籍的業務細節。	詢問	質疑	忘記
巫婆特別提醒調製魔法藥水的材料**順序**非常重要。	順序	步驟	庫存
為了公司的利益，公司決定**杜絕**所有對外的研究成果發表。	杜絕	禁止	聘請
針對這位黑道大哥，警方試圖根據**車牌**資訊進行追蹤。	車牌	司機	里長
趙伯伯和劉伯伯兩人平日**消遣**包括到候選人服務處喝茶聊天。	消遣	娛樂	菜單
小葵在正職之外，也兼差做兒童**繪本**創作的工作。	繪本	圖書	劇團
考上相關科系後，表姊開始關心**時尚**消息以避免資訊過時。	時尚	潮流	鄉土
一直住在偏鄉，老李從來沒有機會利用**火車**旅行的經驗。	火車	鐵路	寬頻
工讀生希望新來的朱大哥可以**依循**過去的方式分配工作。	依循	按照	摒棄
上個星期貝貝仔細整理各家公司**薪資**狀況，以排定求職順位。	薪資	待遇	盤勢
上頭來函指示本月將檢討此區警官**管轄**範圍的重新分配。	管轄	監督	貪污
指揮官聽取過報告之後，認為**情勢**尚未穩定，不可輕舉妄動。	情勢	局面	士兵
本基金會要求每位工讀生穿著**整齊**清潔的便服上班。	整齊	乾淨	繽紛
高老師在講台上教學生如何觀察**血管**組織並記錄在習作簿上。	血管	神經	蝸牛
小黃平常下班的時間都是每天**清早**太陽還沒出來之前。	清早	凌晨	捷運

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Sentence frame	ID	SR	UR
加冕結束後，女王開始接見**王室**成員，典禮也進入尾聲。	王室	貴族	邦交
梁博士的專長是研究宋朝時期**龍袍**圖樣的設計及意義。	龍袍	皇帝	衙門
遊手好閒的表弟終於開始體會**光陰**寶貴逝者難尋的道理。	光陰	歲月	汗水
新秘書發現，市長的信箱裡民眾**請願**內容真是五花八門。	請願	訴求	謾罵
小芸把家當都搬到新家，決意**斷絕**過去的人際關係專心創作。	斷絕	脫離	飼養
這次招標過程中，安和企業遭到**仇家**抹黑，喪失參與的權利。	仇家	敵人	村民
脫下警察制服之後，阿輝選擇一個**安逸**舒適的退休生活。	安逸	舒服	熱鬧
這次大會預計邀請兩位知名**文豪**演講，鼓勵後進從事創作。	文豪	詩人	律師
該國的許多非營利組織擔心**腐敗**嚴重的政治會影響組織運作。	腐敗	惡化	救援
這次的舞台兩側規畫作為**燈具**放置的空間，禁止他人進入。	燈具	器材	鷹架
小儒徹夜沒睡覺，為大家製作**標語**準備明天的抗議行動。	標語	口號	禮物
拼布老師為學員示範在錢包**角落**縫製可愛的圖案。	角落	邊緣	式樣
小宛負責的事項是整理櫃檯並分送**信函**包裹到各個處室。	信函	郵件	案件
離去十年後歸來，小冬發現**兒時**故鄉樣貌已經難以辨認。	兒時	童年	夥伴
在這次事件中，同學都十分**欽佩**事發當下班長的勇氣與沉著。	欽佩	崇拜	遵守
在新的一輪審查中，審查委員**刪除**超過一半的原提案。	刪除	淘汰	抨擊
這次座談會為參與的同學準備**贈品**當作日後紀念。	贈品	禮物	麵包
探險隊隊長最後決定把前方**綠洲**當作下一階段的探險目標。	綠洲	沙漠	瀑布
今年三月的車展上展出許多**豪華**車種，令人目不暇給。	豪華	昂貴	怪異
在協商中，廠商與政府代表**估算**工程費用的結果差異很大。	估算	衡量	刁難
剛回家的哥哥認真的講述上週街頭**慘案**調查過程的點點滴滴。	慘案	悲劇	攤販
最近新開幕的溫泉旅館，裡面所有**沐浴**設備都是設計訂做的。	沐浴	洗澡	播放
參加服務隊的小東每週固定**探視**獨居長者和行動不便者。	探視	拜訪	蒐集
樓下伯伯的辦公室裡有許多**證件**等待失主來認領。	證件	護照	貓咪
葉教授的實驗室研究病毒**潛伏**機制的秘密，累積了許多資料。	潛伏	隱藏	挾帶
自古以來這個地區就有眾多**城邦**各自管理自己的領土。	城邦	王國	叢林
報紙大篇幅報導了這位通緝要犯**自首**投案的消息。	自首	坦承	嚐試
黃瑀老師在今年年初決定**退出**補習教育，改做翻譯。	退出	辭職	撰寫
莊博士的論文發現桑族人的傳統**曲調**地區差異非常大。	曲調	旋律	療法
在科技園工作了三年後，明倫開始**渴望**回到鄉村生活。	渴望	嚮往	捐贈
偵辦案件時，警察會從嫌犯**顏面**微妙的變化來捕捉情報。	顏面	臉色	昔日
隔壁老太太在閣樓裡藏了許多**鈔票**零錢，都是她的長年累積。	鈔票	貨幣	刊物
看到小兄妹兩人進到屋內，老婆婆**露出**陰險的笑容。	露出	浮現	點頭
新聞報導說到，連日來的大雨已經**緩和**農曆年以來的旱象。	緩和	紓解	淹沒
由於涉及多位車主，這樁車禍的責任**判別**爭議不斷。	判別	界定	堪稱
阿東研究每個提案的可能**弱點**以及對應的改進方案。	弱點	毛病	搭配

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Sentence frame	ID	SR	UR
為了課堂實驗示範，廖老師買了充滿**肥肉**並且帶皮的豬肉。	肥肉	脂肪	絨毛
幼稚園裡，蕃薯班的老師正在**誇獎**吃飯吃光光的小花和小正。	誇獎	讚美	囑咐
根據新市鎮的藍圖，原本**海灣**週邊的管制區將規劃為公園。	海灣	港口	寺廟
日本來的專家依據本地區**河水**分布的情形規畫新的灌溉系統。	河水	溪流	煤礦
小廷現在的工作是自己開班教授**特技**表演，或自己接案演出。	特技	魔術	咖啡
記得提醒新來的看護，姑媽**年歲**已經不小了，要特別小心。	年歲	壽命	肩膀
叔叔帶著堂哥堂弟去蒐集**柴火**準備晚上的營火晚會。	柴火	木材	羽毛
專家建議可以藉由冥想來緩和平日**煩惱**帶來的情緒起伏。	煩惱	憂慮	腦海
檢方最後深入調查，發現案情**波及**許多政商界的大人物。	波及	牽涉	宛如
八卦報紙報導議員私藏的所有**寶物**幾乎都是來自貪汙的款項。	寶物	鑽石	毒品
體驗營的特餐有當地居民的特製**香腸**搭配現採的野菜。	香腸	豬肉	糖果
這支記錄片是為了詳實記錄**瀉湖**生態裡的點點滴滴。	瀉湖	濕地	佛教
建築工人們已經準備了許多**泥土**準備進行填平作業。	泥土	砂石	宵夜
歷史博物館最新的展覽展出許多**雕塑**描繪佛陀時期的生活。	雕塑	銅像	陶瓷
在舞台上，帶領抗議民眾的領袖**宣示**抗爭的目的和決心。	宣示	揚言	慶祝
馬老師常常在報紙上寫文章**奚落**對手的立場，毫不留情。	奚落	譴責	剖析
這一帶的居民盛傳，這棟豪宅的附設**花園**其實都是違建。	花園	庭院	店面
每年特定時節皇帝都要前往**祭壇**舉行祭拜祖先和上天的典禮。	祭壇	廟宇	森林
每逢秋季這裡的傣族人就要準備面對**暴雨**帶來的財物損失。	暴雨	洪水	蝗蟲
家隆近來一直很忙，因為部門的系統**缺陷**已經危及公司運作。	缺陷	漏洞	壽命
所有的照片中，小良最喜歡**熱帶**海域拍的那幾張特寫。	熱帶	珊瑚	蜜月
中研院特地派了一個小組分析**震源**位置的地質特性。	震源	斷層	魚類
麗君老師為大家示範她的獨家**減肥**健康操，大家都很有興趣。	減肥	瘦身	烹飪
小花的男朋友至今仍不能**體會**身為設計師的小花趕稿的辛苦。	體會	諒解	敞開
裕翔正在尋尋覓覓，尋找**隊友**參加今年的創業競賽。	隊友	伙伴	義工
依照妹妹的個性，她一定不會按照**習俗**規定的方式舉辦婚禮。	習俗	慣例	章程