

Article

Bilingual Prefabs: No Switching Cost Was Found in Cantonese–English Habitual Code-Switching in Hong Kong

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Abstract: Previous studies on the comprehension of code-switched sentences often neglected the code-switching habit of the specific community, so that the processing difficulty might not have resulted from the change in language but from unnatural switching. This study explores the processing cost of habitual and nonhabitual code-switching. Thirty-one young adults participated in the sentence-reading task with their eye movement tracked. A two-by-two factorial design was used, with Habit (habitual/nonhabitual) and Language (unilingual/code-switched) as the factors. The main effect of Language was observed only in First Fixation Duration, suggesting that the language membership was already identified in an early processing stage. However, for habitual switches, no switching cost in overall processing effort was found, as reflected by Total Fixation Duration and Visit Counts. Our results indicate that the cognitive load was only larger when the switch occurred nonhabitually, regardless of the language membership. In light of this finding, we propose that habitual code-switching might promote the formation of bilingual collocations, or prefabs, which are then integrated into the mental lexicon of the dominant language. Despite a conscious language tag of a foreign origin, these bilingual prefabs are not processed as a language switch in the lexicon.

Keywords: code-switching; mental lexicon; prefabrication; bilingualism; bilingual comprehension



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1. Introduction

1.1. Comprehension of Code-Switching

Code-switching (CS) is a common phenomenon found in many bilingual communities. It demands cognitive control to accomplish, though the amount of effort differs in whether the task involves production or comprehension (Van Hell et al. 2015). In production tasks that required top-down control (i.e., participants were probed to switch to another language by a sign), language switching was effortful and participants needed more time to respond to than nonswitch conditions (e.g., Meuter and Allport 1999; Costa and Santesteban 2004). On the contrary, studies that required bottom-up control (i.e., participants could change to their preferred language at any time) found an opposite trend (e.g., de Bruin et al. 2018; Jevtović et al. 2020). For instance, in the picture-naming task that allowed voluntary switching, bilinguals code-switched without significant costs (Kleinman and Gollan 2016) or even responded faster than staying in the same language (Gollan and Ferreira 2009). The bottom-up approach is closer to reality than the top-down approach, as code-switching is performed voluntarily and not because bilinguals are cued to do so. The dense code-switching poses a low demand on cognition as the speakers retrieve the most available language without needing to inhibit the unwanted one (Green and Abutalebi 2013). In short, voluntary code-switching in production does not require much cognitive effort.

On the other hand, the comprehension of CS is believed to be cognitively costly. Macnamara and Kushnir (1971) found that bilinguals were slower when reading or listening to

sentences with language switches. Reading a code-switched text was significantly slower than reading a unilingual text (Altarriba et al. 1996; Valdés Kroff et al. 2018). Withholding phonetic cues on CS was found to negatively affect CS recognition compared with when cues were provided (Shen et al. 2020), suggesting that bilinguals relied on external information to become prepared for a switch in language. The comprehension of CS is believed to be more cognitively challenging because of the switch in mental lexicons. The processing of an unexpected switch of languages in a CS context requires the interlocutors to switch between different language lexicons (Green 2018). As such, the listener/reader would have been inhibiting the other language during a conversation and had to reactivate it when encountering a sudden CS in the middle of the sentence. The switch in the status of being *inhibited* to *reactivated* in the mental lexicon prolongs the processing time of CS sentences more than the unilingual sentences (Adler et al. 2020; Valdés Kroff et al. 2018). However, these explanations are based on two assumptions: (1) the CS occurrence is unexpected, and (2) the processing of CS requires switching from one language to another.

1.2. The Code-Switching Habit

The occurrence of CS is not always unpredictable. Different societies have their own habits of CS. For instance, Beatty-Martínez and Dussias (2017) found that Spanish–English speakers would use the combination of (Spanish determiner) + (English noun) significantly more often than (English determiner) + (Spanish noun). Within the Spanish determiner they used, the masculine determiner “*el*” was used much more often than the feminine “*la*”. Interestingly, they also noticed that in the CS of (Spanish determiner) + (English noun), the use of the feminine determiner must be followed by an English noun that would have been feminine in Spanish (e.g., *la* spoon, since the Spanish of spoon “*cuchara*” is feminine), while the use of “*el*” could be followed by both masculine and feminine nouns (e.g., *el* fork/*el* spoon, the Spanish for fork, “*tenedor*”, is masculine). In other words, the listeners would have predicted a noun that would have been feminine in Spanish, after hearing the use of “*la*” in the conversation. As the Spanish determiner was used with an English noun, which has no grammatical gender, there is no grammatical rule to confine the use of the Spanish determiners. Nonetheless, the Spanish speakers had this CS habit to restrict the feminine determiner to feminine nouns, so that the violation of the community habit would result in prolonged processing time. Such prolonged processing time has also been demonstrated in an eye-tracking study on Spanish–English code-switching, in which Spanish–English bilinguals were found to gaze at the incongruent use of feminine determiner (*La* + masculine noun) for a longer period than the congruent use (Valdés Kroff et al. 2018). These observations suggested that CS is not as randomly occurring as it seems, and there might be habitual switching that is specified in each community. Previous studies often neglected the habitual CS pattern of the society and tested the participants with unnaturally code-switched stimuli. Thus, the artificially made stimuli might consist of unfamiliar switches that create the cognitive load in comprehension (Valdés Kroff et al. 2020). The prolonged reaction time did not represent the demand of processing the language change, but rather, the processing of the abruptness.

In this paper, we explore the CS pattern of Hong Kong Cantonese–English and its cognitive load in comprehension. CS is ubiquitous in Hong Kong, both in spoken and written form. In Myers-Scotton’s (1997) Matrix language Frame Model, the Matrix Language is the one that provides the abstract grammatical frame, and the Embedded Language is inserted within the matrix. In Hong Kong, it is more common to have Cantonese as the Matrix Language and English as the Embedded Language than vice versa. Many studies have noticed the phenomenon of embedding English words or phrases into Cantonese sentences, especially in informal contexts (Gibbons 1987; Pennington 1998). Some even described that the conversation in pure Cantonese was “unrealistic” and would “slow down communication” (Chan 2018; Li and Tse 2002; Sung 2010). The insertion of certain L2 words into the otherwise-L1 sentence does not occur randomly and is not based on individual preferences but on a community norm. Consistent with Beatty-Martínez and

Dussias's (2017) observation of Spanish speakers, there is an unspoken rule of when to CS and when not to within the community. Some words are more habitually expressed in the L2 (English) during the otherwise fully L1 (Cantonese) conversation. In other words, people prefer using the L2 instead of the L1 equivalent for certain words. This includes nouns (e.g., printer, locker), verbs (e.g., book, search), and adjectives (e.g., sweet, cute) but less often adverbs and function words, similar to the phenomenon observed in the previous literature (e.g., Van Hout and Muysken 1994). Similarly, some words are more likely to be expressed in L1 than in L2, so that a CS of it would be unfamiliar to the locals of that community. In this case, the use of an L2 is thought to be incompatible in the sentence, even though it provides the same meaning conceptually.

1.3. The Bilingual's Mental Lexicon

The parallel activation of the two languages of a bilingual is well-documented. For instance, Shook and Marian (2019) found that English–Spanish speakers looked at the image of a shovel more than the unrelated distractors when asked to click on a “duck” in English because the two words were phonologically similar in Spanish (*pato* and *pala*). The results replicated the classic findings of the Russian–English pair (“*marku*–*marker*”) from the same author (Spivey and Marian 1999). Mishra and Singh (2014) found a similar effect in bilingual coactivation from the Hindi–English pair. Collectively, these findings suggested that the two languages are always activated but with a different degree of strength.

How bilinguals organise and manage their languages has always been a hot topic in psycholinguistics research. Many interesting frameworks have been proposed for bilingual speech production, including The Revised Hierarchical Model (Kroll and Stewart 1994) and The Inhibitory Control Model (Green 1998). In terms of bilingual word recognition, the Bilingual Interactive Activation (BIA, Van Heuven et al. 1998) is probably the most prominent one. The original model focused on orthographic representation only and was later revised as “BIA+” (Dijkstra and van Heuven 2002). In this model, the input of a letter string firstly activates the orthographical code and its neighbours in both languages. The orthographical code then activates the associated phonological and semantic codes. The BIA+ model assumes nonselective access of an integrated lexicon. If the integrated lexicon framework is correct, then retrieving the L1 or the L2 of the same concept should be essentially the same as long as the two languages have similar levels of proficiency. In contrast, if the two lexicons are separated, then we should be observing a prolonged response in switching because of the need of retrieving items from another lexicon.

On the other hand, there have been suggestions that words consciously known for their foreign origin have been incorporated into another language because of being constantly switched into that language (Lipski 2005). This opens up a third possibility: the lexicon is not organised exclusively based on the language origin, but on how people use it. Our language is never built from scratch but from a large number of prefabs that dominate our lexicon (Bolinger 1979; Wang 1991). Prefabs are phrases with component parts that commonly co-occur in speech, which a strong collocational bond has developed. It has been well observed that a language beginner would make use of the prefabs for easier interaction because the speaker would not have to construct their sentence from scratch (Hinkel 2018). Children were reported to have as much as 60% of their utterances being prefabs (Lieven et al. 1997). As the prefabs are constructed from the input of language habit from the community (Bolander 1989), if CS is a common phenomenon in the community, then it is possible that this habitual CS would turn into a prefab of the L1 even when it was originally from another language. On the surface, the language membership of the words in this study could be easily identified because of the different scripts. However, these habitually code-switched words (e.g., *server*, *file* and *folder*) have been used in Cantonese so frequently that they have developed collocational bonds with certain Cantonese words. In other words, these words might be prefabricated and processed the same way as the L1 words.

Some might argue that the hypothetical bilingual prefabs are cases of borrowing instead of CS. Established borrowing (Poplack and Meechan 1995) is narrowly defined as “the words listed in the dictionary” (Stammers and Deuchar 2011), which have been transcribed into Chinese character representations and thus integrated into the Cantonese phonology. The debate on the distinction between CS and borrowing has not yet reached a satisfying conclusion (Poplack 2018; Treffers-Daller 1991). This was not the focus of our study, therefore, we avoided using any established borrowing as part of the stimuli so as not to confound the experimental conditions.

1.4. Current Study

This paper investigates the cognitive load in processing habitual and nonhabitual Cantonese–English code-switching in Hong Kong using a sentence reading task with an eye-tracking method. Eye tracking provides an ecologically valid method of collecting data during comprehension (Valdés Kroff et al. 2018). The eye-tracking data include what spot participants are looking at, for how long they are looking at it (“fixation”) and the movement between each fixation (“saccade”). Eye movement is believed to be associated with the cognitive and attentional demands of a task (Huang et al. 2022). It allows researchers to understand the cognitive effort required for each segment of the sentence in a detailed way.

Cantonese is principally a spoken language. The Standard Written Chinese, based on primarily Mandarin, is used in formal written situations (e.g., on official documents and literature). In informal situations (e.g., on social media and soft news), Written Cantonese is more commonly used in Hong Kong, especially among the younger generations. Written Cantonese is defined as the “spoken Cantonese represented with written symbols” (Bauer 1988). Table 1 shows the examples of the lexical and syntactical differences between Standard Written Chinese and Written Cantonese. We limited our study to Written Cantonese because technically, CS is not allowed in Standard Written Chinese.

Table 1. Examples of the differences between Standard Written Chinese and Written Cantonese. Romanisation is performed with Jyutping by the Linguistic Society of Hong Kong and the written form of Cantonese follows the most adopted one in Hong Kong.

English	Standard Written Chinese	Written Cantonese
He/She	他/她 [taa1]	佢 [keoi5]
's (possessive marker)	的 [dik1]	嘅 [ge3]
What	甚麼 [sam6 mo1]	咩 [me1]
You go first.	你先走。 [nei5 sin1 zau2] (you/first/go)	你走先。 [nei5 zau2 sin1] (you/go/first)

Whether there is a parallel activation of two separate lexicons or a unitary lexicon of both languages is still under debate (Brysbaert and Duyck 2010; Kroll et al. 2010). We hypothesised that the mental lexicon does not distinguish the word identity solely based on the origin. Instead, the organisation is modulated by language experience. For habitual code-switches, these terms with an L2 language membership would be prefabricated (Wang 1991). Then, the bilingual prefabs would enter the dominantly L1 lexicon. As a consequence, the processing of the prefabs would be no different from that of an L1 term.

2. Materials and Methods

2.1. Participants

Thirty-two university students participated in the experiment, but one male was rejected due to a significantly lower accuracy rate compared with the others (*z*-score = −4.54). Only the remaining thirty-one participants were included in the analysis (15 M, 16 F, *M*_{age} = 21.30, *SD*_{age} = 1.88). All the participants were born, raised and educated in Hong Kong; therefore, their language usage is believed to represent the general younger population in Hong Kong. They all spoke Cantonese as their mother tongue and in daily activities and used English as the medium of instruction in the university. All participants

began learning English around the time when they started formal education ($M_{AOA} = 3.58$, $SD_{AOA} = 1.61$). The average self-rated fluency was 5.73 ($SD = 0.95$) for Cantonese and 4.33 ($SD = 0.9$) for English on a Likert scale of 1 to 7, with 7 being the most fluent. The Shipley score (Shipley 1940), an English vocabulary test, indicated that for all research participants Cantonese was the more dominant language compared with English ($M = 18.10$, $SD = 5.75$; the maximum score obtainable is 40).

2.2. Materials

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Human Subject Ethics Subcommittee of the Hong Kong Polytechnic University (Ref. No: HSEARS20200609002, date of approval: 14 June 2020).

A two-by-two eye-tracking study was designed with two variables: (1) Habit (Habitual/NonHabitual), whether the word was presented in the expected language, and (2) Language (Unilingual/Code-switched (CS)), the language of the critical stimulus presented in the trial. The sentences were presented in one line in the centre position of the computer screen in size 28 of Microsoft JhengHei font. Participants were instructed to read and fully understand the sentence before pressing the spacebar to move on. They had to answer with a mouse click a two-choice question regarding the sentences after every trial to ensure they had fully comprehended the stimuli. The stimuli were all in the format of "XXXXXX, XXXX(critical)XXXX." to ensure similar effort in processing before the critical words across trials and to avoid the sentence wrap-up effect (Rayner et al. 1995; Conklin et al. 2018). The critical word in each trial was the Area of Interest (AOI) to be analysed. See Figure 1. Note that as the CS in Hong Kong was predominantly achieved by inserting English items in a Cantonese sentence instead of vice versa, this study, therefore, only examines one switching direction.



Figure 1. Example of the stimuli and the AOI. In each trial, a one-line sentence would be presented to the participants. The critical word was marked with a blue square in the figure as the Area of Interest (AOI) to be analysed. The blue square was for illustration only and was not visible to the participants. The stimulus is translated to "There's skill in barbecuing chicken wings, you have to add honey to make it work.", with "honey" being the AOI marked in blue.

The experiment was conducted inside a sound-proof booth. Although it is not a must to conduct the eye-tracking experiment in one, doing so has the added advantage of minimising distraction by the environment. The eye-tracking data were collected using a desk-mounted Tobii Pro machine and analysed with SPSS version 25. Participants sat approximately 65 cm away from the screen. A calibration with nine dots was performed for each participant at the beginning. During the calibration, participants were asked to keep gazing at a red dot that moved around the screen and stopped at nine specific spots. This would allow the machine to locate the eyes of the participant. A practice

trial of two sentences was provided before the critical experiment. After the eye-tracking experiment, participants completed a questionnaire on their language background and the Shipley vocabulary test (Shipley 1940) to assess their English proficiency. Participants completed the eye tracking, the questionnaire and the Shipley test in one day. Including the calibration, each eye-tracking session was about 20 min long. The Shipley and the Language Background Questionnaire took another 20 min to complete.

Habit and sentence plausibility were rated by two separate batches of university students. The first author, who is a local of Hong Kong, composed a total of 255 sentences. Part of the critical stimuli was inspired by Chan et al. (2005), and we modified the sentences to fit in the format of this experiment. Students ($N = 42$, $M_{age} = 18.88$) were asked to rate their preference of language usage in it. The students were asked to rate on a Likert scale from 1 to 7, with 1 being *Must use English* and 7 being *Must use Chinese*. Respondents were instructed to choose (8) *Neither* if they thought neither of the options was natural, and those rated as *Neither* by more than one respondent were excluded. Sentences with an average rating ≥ 6 were considered as *Habitual-Unilingual*, and those with ≤ 2 were *Habitual-CS*. Their translation equivalents were used as the *Non-Habitual* conditions, and those scored between 3–5 (no preference in the choice of language) were used as *fillers*. For example, the word “魚蛋 (fish ball)” scored 6.74, and therefore the presentation in Chinese was considered as *Habitual-Unilingual* condition, while the presentation of its translation equivalent “fish ball” was considered as a *Non-Habitual-CS* condition (see Table 2). Another batch of students ($N = 56$, $M_{age} = 19.16$) rated the reasonability of the sentences on a Likert scale of 1 to 7, with 1 being *Very unreasonable* and 7 being *Very reasonable*. Only sentences that matched the code-switching criteria and with an average of ≥ 5.5 in reasonability were included in the study. The experimenters then selected 40 sentences each for L1 and L2 conditions and 20 as fillers. The stimuli were separated into two lists, so the participant would not view the same item in two different languages. For each list, the presentation order was pseudorandomised into four versions to reduce the order effect, each consisted of the same set of stimuli but in different orders. Participants would only view one of the four versions.

Table 2. Examples and the translation of the four conditions in the experiment. The critical word was bolded in each example for illustration only. No special formatting for the critical words was made in the actual experiment. English translation is provided in italic.

Habit	Language	Example
Habitual	Unilingual	街頭小食首選，當然就係 魚蛋 加辣油啦。 (As for the top choice of street food, surely it's the fish ball with spicy sauce.)
Habitual	Code-Switched	我交唔到功課，係咪學校 server 又唔得啦？ (I can't submit my homework. Is the server down again?)
Nonhabitual	Unilingual	我交唔到功課，係咪學校 伺服器 又唔得啦？ (I can't submit my homework. Is the server down again?)
Nonhabitual	Code-Switched	街頭小食首選，當然就係 fish ball 加辣油啦。 (As for the top choice of street food, surely it's the fish ball with spicy sauce.)

We avoid using established borrowing (defined as “dictionary-attested words” in this study; Stammers and Deuchar 2011) because their foreign origin might be a potential confound for the “unilingual” condition. We define “code-switch” as words that have not yet integrated morphologically and that the concept has an alternative expression in pure Cantonese. For instance, “巴士/baa1 si2/bus” has entered the Cantonese dictionary and has no other possible pure-Cantonese expression to name it. Therefore, it is considered as “borrowing” and is not included. On the other hand, “server” is not yet morphologically integrated and could be named in pure Cantonese as “伺服器/si6 fuk6 hei3/”. Therefore,

“server” is considered as “code-switch” in this study. See Table 3 for comparison. We are aware of the constant change in language and dictionary is not the timeliest measurement (e.g., “巴打/baa1 daa2/bro” has morphologically integrated but not yet entered the dictionary). The ambiguous expressions that could not be classified by these criteria are also excluded from this study to avoid possible confounds. We have also avoided those with partial lexical integration (e.g., T恤/ti1 seot1/T-shirt), and those that had not originated from English (e.g., 卡拉OK/kaa1 laa1 OK/karaoke), for better control of the experimental conditions.

Table 3. Definition of “borrowing” and “code-switch” in this study. We only focused on “code-switch” in this experiment.

	Dictionary Inclusion	Morphological Integration	Pure-L1 Alternative Naming	Example
Borrowing	Yes	Yes	No	巴士 (bus)
Code-switching	No	No	Yes	Server

3. Results

3.1. Accuracy

To ensure that the participants comprehended the sentence and not just flashed through it, they had to answer a question regarding the content of the sentence after every trial. The average accuracy was 99.10% ($SD = 0.01$), with the lowest being 97%. It showed that the participants understood the sentences before moving on to the subsequent trial. No difference was found in the accuracy rate between all pairs of conditions ($ps > 0.168$), indicating that neither the switch in language nor the expectancy of the switch affected the understanding of the sentences.

3.2. Eye-Tracking Measurements

The eye-tracking method provides many metrics that capture different processing stages in comprehension. Following the traditions in psycholinguistics (Staub and Rayner 2007), the first fixation duration, total visit duration, fixation count and visit count were analysed. The stimuli were all in the format of “XXXXXX, XXXX(critical)XXXX ”, and the critical word in each trial was the Area of Interest (AOI) to be analysed. See Table 4 for the mean and the standard deviations of the four conditions in each metric.

Table 4. Table of the mean and standard deviations (in brackets) of the different metrics analysed.

Metrics	Habitual-Unilingual	Non-Habitual-Unilingual	Habitual-Code-Switched	Non-Habitual-Code-Switched
First fixation duration	227.90 (39.97)	240.66 (31.29)	213.20 (28.54)	213.31 (24.06)
Total visit duration	432.27 (154.70)	591.35 (205.57)	423.86 (131.72)	481.21 (229.69)
Fixation count	1.84 (0.45)	2.37 (0.63)	2.00 (0.50)	2.19 (0.83)
Visit count	1.64 (0.36)	1.93 (0.49)	1.70 (0.44)	1.81 (0.53)

The first fixation duration refers to the time a subject fixated inside the AOI for the first time. It reflects the earlier stage of processing of the word information, for instance, lexical access (Cook and Wei 2019). A main effect of Language was found, $F(1,30) = 18.63$, $p < 0.001$, $\eta_p^2 = 0.38$. Participants required a longer time to read unilingual conditions ($M = 234$ ms) than CS conditions ($M = 213$ ms). Neither the Habit effect ($F(1,30) = 2.83$, $p = 0.103$, $\eta_p^2 = 0.09$) nor the interaction ($F(1,30) = 1.87$, $p = 0.182$, $\eta_p^2 = 0.06$) was significant. See Figure 2a.

Total visit duration refers to the total amount of time the participants spent inside the AOI, including both the fixations and the saccades, and both the first encounter and the regressions (revisiting the AOI after moving away from it once). It is believed that the longer duration is an indicator of greater difficulty in comprehending the information (Cook and Wei 2017). An interaction between Language and Habit was found, $F(1,30) = 9.37$,

$p = 0.005$, $\eta_p^2 = 0.24$. A simple effect analysis found that the duration was significantly different between the Habitual-Unilingual ($M = 432.27$ ms) and Non-Habitual-Unilingual ($M = 591.35$ ms) conditions, $t = -7.63$, $p < 0.001$. Moreover, participants spent longer reading the Non-Habitual-Unilingual condition ($M = 591.35$ ms) than the Non-Habitual-CS condition, ($M = 481.21$ ms), $t = 4.34$, $p < 0.001$. No significant difference was found between the Habitual-Unilingual and Habitual-CS conditions, $t = 0.51$, $p = 0.612$. See Figure 2b.

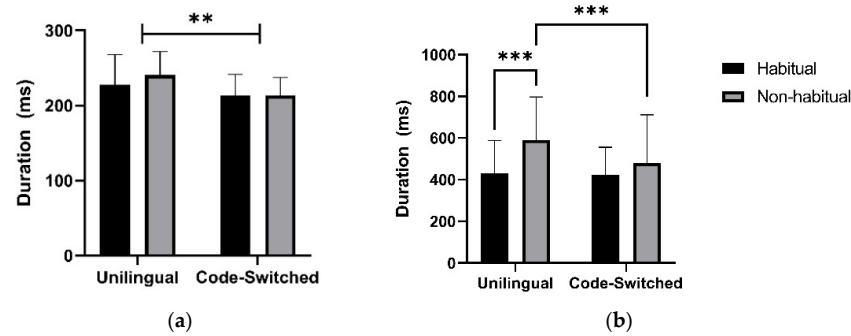


Figure 2. Comparison of (a) the first fixation duration and (b) the total visit duration. *** = $p < 0.001$, ** = $p < 0.01$.

Fixation count is believed to indicate the processing difficulty of the AOI (Cook and Wei 2019). There was an interaction between Language and Habit, $F(1,30) = 10.13$, $p = 0.003$, $\eta_p^2 = 0.25$. Simple effect analysis found that participants fixated more in the Non-Habitual-Unilingual condition ($M = 2.37$) than the Habitual-Unilingual condition ($M = 1.84$), $t = 7.03$, $p < 0.001$. They also fixated more in the Habitual-CS condition ($M = 2.00$) than the Habitual-Unilingual condition ($M = 1.84$), $t = 2.22$, $p = 0.034$. See Figure 3a.

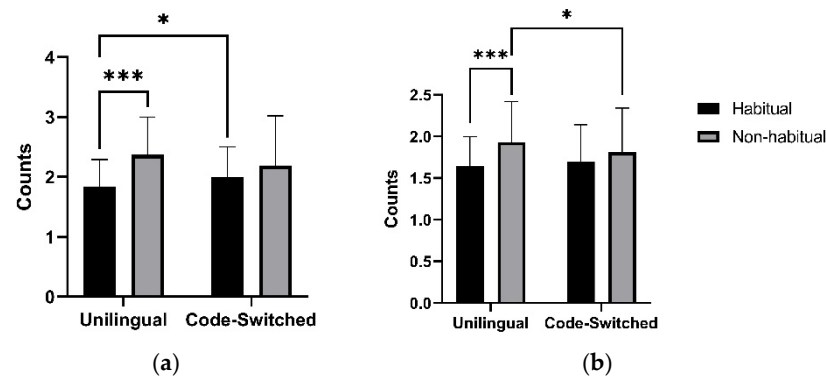


Figure 3. Comparison of (a) the fixation count and (b) the visit count. *** = $p < 0.001$, * = $p < 0.05$.

Visit count reflects the difficulty in processing by calculating the number of times the subject visited the AOI. If the participant had to revisit after moving away from the AOI, it might indicate that there was some uncertainty in their first processing. There was an interaction between Language and Habit, $F(1,30) = 9.49$, $p = 0.004$, $\eta_p^2 = 0.24$. Post hoc analysis found that participants had to regress more for the Non-Habitual-Unilingual condition ($M = 1.93$) than the Habitual-Unilingual condition ($M = 1.64$), $t = 5.45$, $p < 0.001$. They also regressed more in the Habitual-Unilingual condition ($M = 1.93$) than the Habitual-CS condition ($M = 1.81$), $t = 2.21$, $p = 0.035$. No significant difference was found between the Habitual-Unilingual and Habitual-CS conditions, $t = 1.31$, $p = 0.199$. See Figure 3b.

4. Discussion

Previous studies have reported that code-switching (CS) requires additional cognitive resources to process because (1) CS occurs unexpectedly so that the listener/reader would not be prepared for it, and (2) bilinguals have to switch from one mental lexicon to

another. This paper investigated the cognitive load in processing habitual and nonhabitual code-switching in Hong Kong Cantonese–English using a sentence-reading task with eye movement tracked. We hypothesised that for the habitual switch, the terms with an L2 language membership would be prefabricated and the bilingual prefabs would enter the dominantly L1 lexicon (Wang 1991). If the hypothesis was correct, then there should be a significant difference between the Non-Habitual and Habitual conditions only, regardless of the language in which it was presented.

4.1. No Switching Cost for Habitual Switch

In the study, a significant difference was found between the Habitual-Unilingual and Habitual-CS conditions for the fixation count, but not for the total visit duration and visit count. The first measurement is believed to reflect an ongoing process while the latter two are indicators of the overall processing effort. It shows that while there was a difference in cognitive demand in processing different languages in the ongoing stage, the difficulty of comprehension lay in the nonhabitual use of language, but not in the switch in language itself.

In both total visit duration and visit count, we found that the Habitual-Unilingual condition was not significantly different from the Habitual-CS condition. The finding replicates an early study showing that the reading of a naturally mixed Cantonese–English passage took similar time and effort as that of a pure-Cantonese passage (Chan et al. 1983). On the other hand, there was a significant difference between the Non-Habitual-Unilingual and Non-Habitual-CS conditions. This indicated that the comprehension process of the Habitual and Non-Habitual conditions was different. The result is consistent with previous studies that emphasised the naturalness of CS stimuli (e.g., Blanco-Elorrieta and Pylkkänen 2017). Gullifer et al. (2013) reported no significant switching cost from the type of CS that bilinguals frequently engaged in. Similarly, Adamou and Shen (2019) investigated the switching cost of Romani–Turkish, which has a well-established CS structure in the community identical to the situation reported in the current paper. They found no switching cost in more frequently used CS patterns. The authors believed that language processing adapts to the expectations based on language experience.

We went a step further to suggest that the language experience might shape our mental lexicon and that bilingual prefabs (Wang 1991) might be formed. Prefabrication is a well-studied phenomenon and researchers believe that it lightens the burden on speech production and comprehension (Ziafar and Namaziandost 2019). While many studied prefabrication within a single language (e.g., Granger 1998; Perera 2001; see also Quick et al. 2018; and Gaskins et al. 2021), we believe that bilingual prefabs could also be formed after sufficient language exposure to the bilingual word combination. Moreno et al. (2002) conducted an EEG experiment in which they found that the processing of a code-switch was less costly than processing an unexpected within-language item. Similarly, Yacovone et al. (2021) compared unexpected within-language items and unexpected switches of language and found that code-switching did not induce additional processing effort. Instead, it was the unexpected lexical usage that created the processing difficulty. Although by “expectancy” the above two studies referred to the cloze probability of familiar phrases (e.g., “out of sight, out of . . . mind/brain/mente (mind)”) while ours referred to the community norm, it supported our hypothesis that it is not the switch in language that induces greater effort in processing. Instead, it is the unexpected usage (in our case, the Non-Habitual conditions) that increases the difficulty in processing.

The network science approach provided an insight into the overall picture of the semantic organisation. Xu et al. (2021) constructed a semantic network based on two CS corpora. The algorithm detected two groups of closely connected nodes for each of the language pairs (Mandarin–English and English–Spanish). They found that each group was dominated by one language with a small percentage of words from the other language in it. They concluded that the two language lexicons were largely separated, each with a small proportion of words from the other language. We believe that the bilingual prefabs,

as demonstrated in the present study, have provided evidence that is consistent with [Xu et al.'s \(2021\)](#) view.

4.2. Bilingual Comprehension

According to the BIA+ model, orthographical information is the first to be activated by the visual input. Only when the orthographical code is activated would the associated phonological and semantic codes follow. Specifically, the BIA+ model emphasises that similar orthographic candidates would also be activated, regardless of the language. In the present study, the two languages (Written Cantonese and English) did not share the same writing system, and therefore no orthographically similar words would be activated. The orthographical differences should provide an early hint for language membership. The first fixation duration is considered to reflect the early processing of words, including the highly automatic word recognition process ([Conklin et al. 2018](#)). In the present study, only Language effect, but not the Habit effect nor an interaction, was found in the first fixation duration. The result suggests that in the earlier processing stage, the surface identity of the word was distinguished.

A difference was found between the Habitual-Unilingual and Habitual-CS conditions for the fixation count, but not in either the total visit duration or the visit count. The result indicates that even though the language membership was identified in the earlier processing stage and might affect the ongoing processing, the overall effort in comprehending the two Habitual conditions at the end was similar. On the other hand, the Non-Habitual conditions were found to be different in the later processing stage.

Figure 4 illustrates the processing stage of the prefabs. Under the bilingual prefabs interpretation, as discussed in the above subsection, we believe that as the habitual switches have been integrated into the dominant lexicon as a prefab, there is no need for the readers to switch to the other lexicon. Readers in our study were processing these prefabs as if they were unilingual sentences despite a conscious language membership tag, and the semantic meaning was easily retrieved from the dominant lexicon. As the sentences were primarily Cantonese and the dominant language of the subjects was Cantonese, the dominant lexicon consisted of mostly Cantonese words and English prefabs, but not the other way round. On the contrary, participants could not retrieve the meaning of the Non-Habitual switches in the dominant lexicon. They would have had to inhibit the dominant lexicon and activate the less dominant one to retrieve the meaning, resulting in the general slowing in the Non-Habitual switches. From previous studies, the switching from the more dominant L1 to L2 generated a larger switching cost than vice versa, because the suppression and reactivation of the more dominant L1 were harder ([Meuter and Allport 1999](#)). Our result is consistent with this view, as we found the participants read the Non-Habitual-CS condition faster than the Non-Habitual-Unilingual condition in the total visit duration.

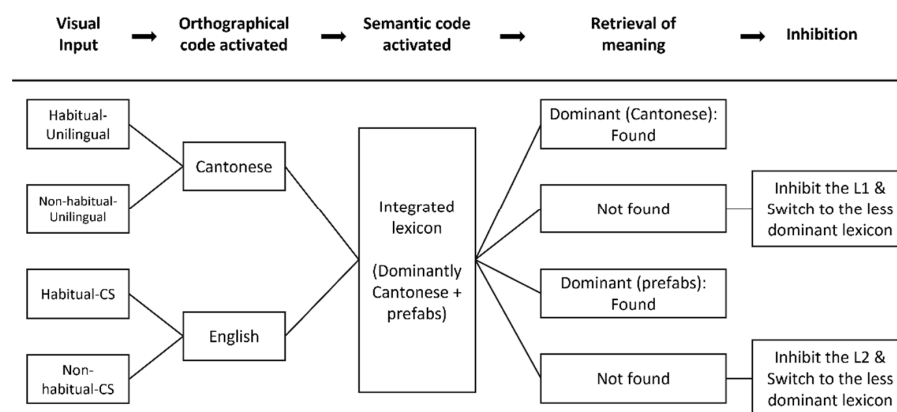


Figure 4. An illustration of the bilingual prefab's processing model. The orthographic difference between the two languages in our study provides an early hint for language membership. As the sentence is primarily Cantonese, the default lexicon activated is the one with Cantonese as the dominant language. The Habitual-Unilingual and the Habitual-CS (as prefab) are retrieved from it. However, an inhibition of the dominant lexicon and the activation of the nondominant lexicon are needed to retrieve the Non-Habitual items.

4.3. Limitation

This study emphasises how the environment would impact the language, specifically how the language input from the community influences the organisation of the mental lexicon. In Hong Kong, some of the words are more habitually code-switched. The frequent input of code-switching of certain words from the community contributed to the formation of the bilingual prefabs in the lexicon. However, different language usages might influence how the CS is being processed. For instance, in places where CS is commonly performed in a non systematic manner, a special mechanism to process the code-switching might be formed. Frequent code-switchers were found to perform better in the cognitive control tasks, suggesting that they might have developed a system for switching (Han et al. 2022). In addition, it was found that frequent code-switchers have larger thalamus and caudate nucleus, which are the brain regions responsible for language switching (Korenar et al. 2022). It is less likely the case in Hong Kong because it would be predicted that both habitual and nonhabitual CS are being processed similarly with that mechanism. However, the current study and an earlier study in Hong Kong (Chan et al. 1983) both reported that only habitual code-switching would be processed similarly to a unilingual text, and the nonhabitual CS required a longer time to comprehend.

The CS habit contributed to the mental lexicon of the Hong Kong locals as a natural language input. In other places, for example, in the Cantonese-speaking Chinese American community, the norm might be very different even though the language pair is the same as in the current study. Future studies should pay attention to the naturalistic code-switching habit when designing the stimuli.

5. Conclusions

This study examined the processing of code-switching and its cognitive load through eye tracking. Specifically, we investigated the habitual switching of the Hong Kong Cantonese–English speakers in which CS is so common that the use of the L1 equivalents is thought to be unnatural. We hypothesised that the constant exposure to such code-switches had formed prefabs in the mental lexicon, and such prefabs were organised and processed as part of the dominant language. Our result supports this claim. Although language membership was identified in the earlier processing stage, the overall processing effort suggested otherwise. Whereas an increased processing time was found in nonhabitual code-switches, no switching cost was observed in habitual switches. We suggest that the language experience could shape our mental lexicon, and bilingual prefabs could be

formed as part of the dominant lexicon. The processing of the prefabs was not considered as a “switch” in lexicon even if the speakers knew that the word was from another language.

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