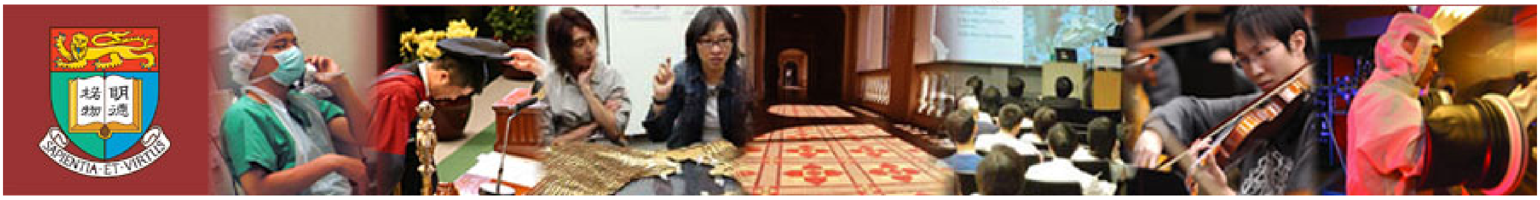

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Development of a verbal inhibitory control task for Cantonese speakers:

A study of proactive interference

Student number: 2006675596

A dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science (Speech and Hearing Sciences), The University of Hong Kong, June 30 2010.

Development of a verbal inhibitory control task for Cantonese speakers:

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Abstract

Previous research has indicated normal English speaking controls were subject to proactive interference (PI) with manipulated semantic and phonological relatedness of distance between probes and list-items (Hamilton & Martin, 2007). We aimed at replicating results to Cantonese participants using negative probe test and to investigate if variation in writing and phonological system would inflict differential inhibitory processing. Relative to the English precedent, healthy participants showed concurrent ability to inhibit irrelevant information when probes are related to previous list. PI was significant on same list trials with semantically-related conditions, but not when they are phonologically-related. Such differential results provided important implications for language specificity where phonological processing units are shorter in Cantonese with mix of consonant-vowel-tone combinations than at individual phonemic level in English (Wong & Chen, 2009). Word frequency, regularity and use of visual strategies may also enhance recognition latency based on familiarity and level of activation during lexical processing.

Key words: Proactive interference, phonological units, frequency, regularity, orthographic facilitation

Introduction

Executive function is associated with the ability to temporally organize purposive behavior, language and reasoning in human. Fuster (2008) defined it as containing intermingled components including attention, working memory (WM) for prospective execution of information, networking with long term memory, decision making, planning, temporal integration of goal directed behavior, monitoring and inhibitory control. According to Friedman & Miyake (2004), inhibitory functions could be differentiated into three separable related functions, i.e. inhibition of proactive interference (PI), prepotent response inhibition, and resistance to distractor interference.

PI, the focus of our study, refers to interference previously presented. Such information was previously relevant but has become redundant when the target is presented after the interfering information. A disruption to inhibit such information would result in a reduced ability to use WM. On the other hand, prepotent response inhibition refers to the ability to suppress dominant, automatic responses as required in anti-saccade task and Stroop tasks. Resistance to distractor interference refers to the ability to focus on current target stimuli and suppression of distracting information as required in tasks like word naming. Unlike PI, the latter two inhibitory abilities do not involve memory requirement during the inhibitory process (Mitchell, Macrae, & Gilchrist, 2002; Olk & Kingstone, 2009) but active maintenance of task goals were essential in face of interference (Friedman & Miyake, 2004).

There is increasing acceptance of the importance of inhibitory control in cognitive studies. Recent works from Hamilton and Marin (2005) provided insights into inhibitory control directions and found dissociation of inhibition between verbal and non-verbal materials. Current WM models (Conway & Fthenaki, 2003) also emphasized the role of interference resistance in WM processing and cognitive functions. Ikier and colleagues examined the effects of age-related cognitive decline and they associated greater interference effect with declined inhibitory strategies such as “checking”, “selection” and “deletion” among aged populations (Ikier, Lixia, & Hasher, 2008). In fact, our understanding of normal inhibitory processes also integrated research in psychology, neuroscience, educational psychology and lifespan development. Deficient inhibition had been postulated in disorders including autism (Kana, Keller, Minshew, & Just, 2007), ADHD (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), obsessive compulsive behaviors (Kalis, Mojzisch, Schweizer, & Kaiser, 2008) and schizophrenia (Soriano, Jimenez, Roman, & Bajo, 2009). Research to identify how inhibitory control may affect the outcome of anomic therapies had been conducted (Yeung, Law & Yau, 2008). Changes in inhibition (Carlson & Wang, 2007) and interference control have also been used to explain cognitive development and age related declines (Olk & Kingstone, 2009). Given the potential significance of inhibitory control in cognitive and psycholinguistic theories and implications on rehabilitation, there is strong incentive for further investigation of the mechanism.

In the study of verbal inhibition, Hamilton and Martin (2007) conducted experiments to show that one patient, M.L. with semantic short-term memory (STM) deficits demonstrated exaggerated PI beyond healthy control participants' range. Their experiment implemented variation of recent negatives task. M.L. and control participants were required to determine if the probe word displayed had been included in the list recently or more distally presented. Results showed that patients with semantic STM deficit had exaggerated PI effect in both semantically and phonological related trials in the same and previous lists. Whereas for individuals without STM deficits, their reaction times (RT) were longer with lower accuracy in recent negative trials than non-recent negative trials. Specifically, Hamilton and Martin's data suggested that one's difficulty in short-term recall may not be due to rapid decay of the semantic representations, but due to abnormal persistence of materials presented previously. The difference in RT under variation of probe recency indicated normal subjects' ability to inhibit previously presented but no longer relevant information and they were more interfered by recently presented material (Rougier, et al., 2005). Although these findings had been useful in reflecting inhibitory control, they were conducted in English and results might not be generalizable to non-English speaking populations.

Our study aimed to investigate the effect of PI on verbal inhibitory tasks through contribution of semantic and phonological relatedness using Chinese characters and Cantonese as phonological case. Past research on PI was mostly conducted in English, therefore the universality of PI in Chinese needs to be established. Unlike English, which alphabetic scripts are represented by letters and in association with individual phonemes, Chinese character, on the other hand represents a morphemic level and its orthography was often considered to be logographic. Each character do not contain components that correspond to specific phoneme or tone, and the orthographic-phonological mapping is generally considered at syllable level, that contain an onset and rhyme unit (Law & Or, 2001). Nonetheless, over 80% of all characters are phonetic compounds, which refer to characters that encompass both semantic and phonetic radical. While semantic radical provides the cue to the character’s meaning, the phonetic radical provides information to its pronunciation. In the example of the word 清 (/tsiŋ1/ ”clear”), it has a left semantic radical meaning “water” and a right phonetic radical 青 with same pronunciation as / tsiŋ1/. Since most Chinese characters contain both semantic and/or phonological information, hence PI may be supported by cognitive functions different from those in an alphabetic system (Law & Caramazza, A., 1995). The mechanisms required in Cantonese may also reflect different interference patterns and has important theoretical and clinical implications. While Lee, Yuen, & Chan (2002) conducted neuropsychological measures on inhibition among Hong Kong Chinese young adults using the Chinese version (CST) of Stroop Colored Word Test (Victorian version), it is arguable that the test mainly measured inhibition of prepotent responses instead of PI. Therefore, detailed studies of suppressing intrusion of previously presented Chinese verbal materials are valuable.

In addition, neuroimaging studies involving neurologically-damaged patients with STM deficits reported different brain systems for inhibiting verbal and non-verbal information (Morimoto et al., 2008; Stephan et al., 2003). Research results showed that control processes in verbal letter detection tasks activated the left anterior cingulated and left inferior frontal gyri, whereas control processes involving visuospatial tasks preferentially involved in right anterior cingulated and intra-parietal sulci. This finding differentiated verbal and non-verbal specificity in brain function and therefore had clinical implications.

On issue of rehabilitation, recent research by Yeung, Law & Yau (2009) correlated one's ability to inhibit competing non-target items and executive functions based on non-verbal measures, such as TONI-3, the Behavioral Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie & Evans 1996) and the Attention Network Test (ANT; Fan, MaCandliss, Sommer, Raz & Psner, 2002). They found that the level of non-verbal inhibition was correlated with subsequent success in a naming treatment and generalization effects. However, as the executive functions measured were not based on verbal tasks, the relevance to language rehabilitation was less apparent. We were therefore motivated to study suppression of verbal interference in Chinese, particularly PI by employing the same verbal inhibitory task in Hamilton and Martin, (2007).

In an attempt to replicate previous experimental results to obtain normative data on the Hong Kong Chinese population, we developed a Chinese verbal inhibitory task with an aim to address several questions. Firstly, would normal Hong Kong Chinese young adults respond differently to probes presented in the same versus previous list as reflected in RT and accuracy, indicating PI variation with respect to the distance between presentation of stimuli and probe? Secondly, given that the study involved both semantic and phonological probes, considering the characteristics of the Chinese writing system and recent findings of phonological processing in Cantonese, would inhibitory processing differ between these two verbal domains in Cantonese?

Using results in Hamilton & Martin (2007) as basis. It was expected that normal Cantonese-speaking subjects in our study would show interference effects on semantic and phonological relatedness only when stimuli and probes are presented in the same but not in previous trials. Examples and explanations of the experimental conditions are illustrated in the Appendix attached. In both phonologically related examples, the item "針" /tsʌm1/ presented in either the current or the previous list, shared phonology with the probe "心" /sʌm1/. It was hypothesized that PI will be inflicted by the shared phonological features. Similarly, in semantically related trials, the probe "笛" (flute) has shared semantic category with one of the list item "鼓" (drum) as both are musical instruments. PI will be invoked when a list item presented in the intermediate previous or the same trial was semantically related to the probe subsequently displayed. In order to illustrate inhibitory mechanism is in place, we hypothesize that our normal Cantonese participants will mirror the English case to suppress the inflicted PI when probe-stimuli distance are lengthened (i.e. probe-stimuli in previous list conditions) but not when such distance are shortened (i.e. under same list condition). Nevertheless, should interferences for Cantonese verbal materials were found to be in atypical patterns, the observations may indicate potentially different inhibitory functions on language specific processing and therefore call for further investigations.

Method

A Chinese recognition probe test in the same paradigm as that in Hamilton and Martin (2007) was administered to examine subjects' susceptibility to PI through manipulating the distance between the list items (i.e. current list versus previous list trials) and the probe. The degrees of semantic and phonological relatedness between the list items and the probes were manipulated to reveal the PI effect.

Participants

Thirty-five native Cantonese undergraduate students were recruited from the University of Hong Kong. They included 18 female and 17 male aged between 18 and 25 with mean age at 21.80.

Apparatus

In each trial, the probe and the list items were presented on a 13.3-in. monitor of a Fujitsu Lifebook laptop computer using the E-Prime program. The characters were displayed at a size approximately 4 × 3 cm in PMingLiu 120 font. Response latencies were recorded to the nearest millisecond by touch-onset relay detected on the response box indicated "yes" or "no" answers.

Stimuli

All stimuli were single Chinese characters. In choosing the characters to be included in the stimulus list, word classes were allocated to each condition in approximately consistent manner with nouns occupied from 59% to 60% in positive and unrelated negative trials. For semantically and phonologically related conditions, nouns accounted from 62.5% to 67.5%. Concerning orthographic-semantic relatedness, interference effect caused by additional orthographic similarities in semantically related words needed to be delineated. This was overcome by including list items which are orthographically similar to the target probe but shared no semantic features with the probe in unrelated negative trials. In addition, serial position of the interfering list item had also been balanced. Note that “semantically relatedness” were not exactly synonyms, but are judged by the investigator of the study in accordance with the study by Bartha, Martin and Jensen.(1998).

There were six experimental conditions in that task as illustrated in the Appendix. The relationships between stimuli and probes included (a) *positive* (i.e. the probe appeared in current list), (b) *semantically similar-pre list* (i.e. the probe in current list shared semantic features with one of the list stimuli in the previous trial), (c) s*emantically similar- same list* (i.e. the probe shared semantic features with one of the stimuli in current list), (d) *phonologically similar- prelist* (i.e. the probe in current list rhymes the same with one of the stimuli in the preceding list), (e) *phonologically similar-same list* (i.e. the probe rhymes the same with one of the stimuli in the current list), and (f) *unrelated negative* (i.e. the probe shared no features with items presented in the same and previous lists). This last condition served to contrast with conditions in (b)-(e). It was expected that PI effect will occur when a list item presented was phonologically or semantically related to the probe in the same trial but not in the previous list.

Participants were required to complete a total of 640 trials including 120 lists in positive and unrelated negative conditions respectively and 40 lists in each of phonologically related-same list, phonologically related-previous list, semantically related-same list and semantically related-previous list.

Procedures

Participants were tested individually in a sound booth located on 5/F Prince Philips Dental Hospital, Hong Kong. Each participant was given a total of 640 lists of stimuli each containing four Chinese monosyllabic words and one probe. The task was divided into four parts with five blocks of trials in each. Each block contained 32 trials and was preceded by 10 practice trials which could be skipped by participants should they choose to directly commence the block. Within each part, the blocks were randomized but with the order of trials in each block fixed. Four single characters were presented serially for 750 ms each with a 100 ms inter-stimulus interval. The fourth character was followed by a 100 ms interval, and then a row of **** was presented for 1000 ms followed by the probe word for 750 ms. Participants were allowed 10 s to provide a response. A break was allowed after completion of each block and participants might resume the test through pressing any key on the keypad. Each part roughly required 25 min to complete.

Among the total 35 participants, 28 of them completed the experiment in two separate sessions, while 7 participants attended in three individual sessions administered with at least two days apart typically within one week. Stimuli were presented using the E-prime software program. Subjects were instructed to respond as quickly as possible after the probe was presented and they were required to press a key on the response box to indicate whether the probe appeared amongst the list of stimuli. Interference would come from semantic, phonological relatedness and distance of presentation between the probe and the interfering list item. Both the accuracy and reaction time (RT) in each trial were recorded and the PI effects in recognition probe test were investigated by comparing the accuracy and RT of the unrelated negative condition with each of the other conditions.

Data analysis

Subjects will be eliminated from analysis if his/her performance was below 70% in any condition and trials with (i) incorrect responses or (ii) unusually long or short responses, i.e. more than ± 3SD. Interference effects on accuracy and RT for each condition were calculated by comparing mean RT of each condition with that of the unrelated negative trials.

Data were analyzed by subject and by item using one-way analysis of variances (ANOVA) with RT and accuracy as dependent measures. The homogeneity assumption was verified by the Levene’s test and sensitivity of the study was substantiated through calculating the power, i.e. the probability of finding statistically significant difference and effect size. Our results had been adjusted for Type I error when using post-hoc analysis on multiple comparisons.

Results

One-way ANOVAs were used to examine how the relationship between the probe and stimulus list under different conditions may affect accuracy and reaction times. Three types of responses were excluded from data analysis: incorrect responses of all trials (5.14%) and reaction times (RTs) that were 3 SDs beyond either participant mean in each condition in the by participant analysis (4.03%) or item mean in each condition in the by item analysis (5.63%). The mean and SD of RT and accuracy under various experimental conditions are shown in Table 1.

Table 1 Mean reaction time and accuracy in different conditions

	Positive	Semantic same list	Semantic previous list	Phonological same list	Phonological previous list	Unrelated negative
By participants (N=35)				Reaction time (millisecond)		
Mean RT	573.34	605.01*	572.45	566.33	572.90	569.53
SD	(123.39)	(146.98)	(131.71)	(119.01)	(133.92)	(120.48)
				Accuracy (%) – Proportion correct		
Mean	91.86*	95.93*	98.57	97.86	97.93	98.09
SD	4.68%	5.04%	1.94%	3.44%	2,23%	2.23%
By items (N=640)				Reaction time (millisecond)		
	320	40	40	40	40	160
Mean RT	570.79	604.64*	564.46	565.38	568.19	566.63
SD	(206.63)	(208.46)	(178.77)	(180.65)	(182.02)	(173.29)
				Accuracy (%) – Proportion correct		
Items	92.05*	95.71	98.43	97.50	97.71	97.89
SD	6.94%	5.41%	2.50%	2.52%	3.89%	2.63%

* Significant interference effect, p<.05.

The results of one way ANOVA by participant (*F1*) and by item (*F2*) are shown in Table 2.

Table 2. One way ANOVA showing significance level of RT and accuracy by participants and by items

			RT	Accuracy
Main effects		*F1*	7.85***	24.24***
			(.20)	(.42)
		F2	6.07***	34.85***
			(.05)	(.21)
Post-hoc results			RT	Accuracy
Unrelated negative				
vs.	Positive	*F1*	ns	***
		F2	ns	***
vs.	Semantically related-same	*F1*	***	0.028*
		F2	0.004*	ns
vs.	Semantically related-pre	*F1*	ns	ns
		F2	ns	ns
vs.	Phonologically related-same	*F1*	ns	ns
		F2	ns	ns
vs.	Phonologically related-pre	*F1*	ns	ns
		F2	ns	ns

Note*:* Insignificant statistical difference: “ns”

Significant interference effect, *$p<.05$. **$p<.01$. *** $p<.001$

Effect size η^2 were shown in parenthesis.

By participant analysis

The Greenhouse-Geisser correction was employed in the repeated-measures ANOVA at confidence level of 95%. The results indicated a significant difference in mean RT with $F_{1(\mathrm{RT})}$ (3.23,109.86) = 7.85, p<.001, $ŋ^2$ = .20 and accuracy $F_{1(\mathrm{accuracy})}$) (3.01,102.47) = 24.24, p<.001, $ŋ^2$ = .42. According to Cohen (1988) guidelines for interpreting strength of association, $ŋ^2$ at values of .02, .13 and .26 correspond to strength of small, medium and large respectively. Therefore our results showed medium strength of association in respect of RT and much larger association in accuracy with sample size of 35 participants.

Bonferroni adjustments were used in post-hoc analyses. The results revealed significantly longer RT in semantically-same trials (*M* = 605.01, *SD* = 146.98) than in unrelated negative trials (*M* = 569.53, *SD* = 120.48) by 35.48 ms. No other significant differences were found.

In terms of accuracy, participants made significantly more errors in positive trials (91.86%) than in unrelated negative trials (98.09%) with *p*<.001. In addition, accuracy in semantically similar – same list trials (95.93%) also showed statistically significant difference from unrelated negative conditions (*p*=.028) with a difference of 2.16%.

In summary, semantically related-same list trials had statistically significant effect on reducing accuracy and prolonging RT of participants. Positive trials also posed interference effects by reducing accuracy in participants’ responses.

By item analysis

By item analysis was conducted using one way between-subject ANOVA at confidence level of 95%. Since the Levene's test showed significant effect ($p<.001$), the assumption of homogeneity was violated. Post-hoc analyses using the Games-Howell (GH) test for "equal variance not assumed" was implemented. With reference to table 2, the results indicated statistical significant effect in both RT and accuracy with $F_{2(\mathrm{RT})}$ (5, 634) = 6.07, p<.001, $\eta^2 = .05$ and $F_{2(\mathrm{accuracy})}$ (5, 634) = 34.85, p<.001, $\eta^2 = .21$, and showed small association on RT but close to large association on accuracy (Cohen, 1988).

Post-hoc analysis revealed significantly longer RT in semantically related-same list trials (M = 604.64, SD = 208.46) than unrelated negative trials (M = 566.63, SD = 173.29), p=.004, with an interference effect of 38.01 ms. No other significant differences were found.

Similar to the results of the by participant analysis, the accuracy of positive trials (92.05%) was significantly lower than that of unrelated negative trials (97.89%), $p<.001$. By item analysis was consistent with findings in positive conditions showing accuracy were significantly interfered with $p<.001$. However for semantically same trials, significant interference in accuracy were only apparent in by-participant analysis with p=.028, i.e. <95% confidence level, but not in by-item analysis with p=0.155, which only revealed 2.18% variance between semantically same and unrelated negative trials.

Discussion

Hamilton and Martin (2007) revealed existence of significant interference effect in RT in same list trials for both phonologically and semantically related conditions in 25 normal English speaking undergraduates. Accuracy on the two conditions showed deterioration, but the difference was not statistically significant when compared with unrelated negative trials. The present study was inspired by Hamilton and Martin's finding to replicate effects in PI inhibition of Chinese verbal stimuli using monosyllabic characters on 35 Cantonese speaking undergraduates. Our results showed concurrent findings with the English precedent that semantically related conditions does present interference effect on RT of normal Cantonese undergraduate subjects. Such interference did not extend to probes when they are matched with items in the previous list and hence illustrated the prevalence of PI and normal subjects' ability to suppress irrelevant information in previous lists. On the other hand, we obtained intriguingly different results regarding phonologically related-same list condition. Instead of an interference effect, the RT in the aforementioned condition seems marginally facilitated by stimuli sharing the same rhyme as the probe under same list condition and its accuracy was comparable with our baseline of unrelated negative condition. Such phenomenon persisted with our extended number of characters per stimuli list from three in the pilot study to four in the present study. Both pilot and current results showed statistically significant interference in RT and accuracy, which were only present in the semantically related same list condition but not in phonologically related trials.

Explanation postulated by Hamilton and Martin (2007), provided evidence for the presence of semantic codes in the STM, which had been ignored by previous STM and WM models (Hamilton & Martin, 2007). Their operative assumption is that in order for previously presented words not to interfere with current processing, memory trace of those prior words must be deleted. Otherwise its persistence would entail PI, which is caused by conflicts between the overlapping features in the probe and lure, and require further processing of the contents in the STM. In healthy English and Cantonese participants, such interference did not extend to probes that were related to items in the previous lists. However in patients with semantic STM deficits, the inspection process of comparing contents in stimuli and probe may be longer and prone to failure as relevant information had not been adequately retained. We hypothesize that such failure to maintain clear representation of features overlapped in stimuli and probe adds decision time as reflected in both the English and Chinese experiment.

For English, the relationship between orthography and semantics were considered to be more arbitrary since at mono-morphemic level, letters do not provide strong cues to meaning (e.g. “pat”, “mat”, “cat” are orthographically similar but bears no resemblance in meaning). In contrast, Chinese were referred to as a system compassing more clues to semantics with the presence of semantic radical which encodes categorical information of the character (e.g. 鋼 “steel” contains the semantic radical of 金 ”gold” on the left which indicates “metal”). Thus regardless of the level of semantic saliency depicted in the two languages, semantic codes contained in words will be activated during processing for dissection and comparison.

Such process will generate PI as shown in both the English and Chinese test results.

By-item analysis had also been conducted in our present study, which showed concurrent results as in the by-participant analysis with significant PI reflected as prolonged RT in semantically related-same list trials only. We suggest that the differential phonological interference on verbal stimuli of the two languages may be attributable to how the two different writing systems, i.e. alphabetic script in English, and logographeme represented in Chinese orthographic system, are mapped to sound. (Law & Leung, 2000).

As pointed out in Toyoda and Scrimgeour (2009), disregarding the type of scripts, readers develop structural and functional recognition of the word properties with increased exposure to the script. However, as sub-lexical units which are crucial for processing phonological or morphological components are not homogenous, the analytical procedures required may varied among scripts. In their study on script specific awareness, readers develop understanding of how sub-lexical units corresponded to phonological and morphological information during orthography-phonology and orthography–morphology mapping. Such script specific awareness may be governed by the types of processing units covered under different orthographies, which in turn be varied in their representation of spoken languages. In English, letters are the orthographic units of the alphabetic writing system which represent phonemes. Readers need to notice specific orthographic features such as letter probabilities, frequency of occurrence of the positions and patterns in sequential redundancy (Perfetti, 1986). For Chinese, the writing systems are morphosyllabic with orthographic units represented by symbols which denote syllables and each character carries a component of sound and meaning. These differences would result in diverse orthography to phonology mappings and be processed via different underlying cognitive processes (Coltheart, Rastle, Perry, Langdon & Ziegler. 2001).

In addition, Chinese orthographic units can be classified into simple characters or compound characters. The former only comprise roughly 10% of characters in common use and there are no direct linkage between their sound and meaning but directly derive them from pictographic or ideographic symbols. Compound characters, on the contrary, contain functional components which may provide relevant information on semantics or phonetics (Leck, Weekes, & Chen, 1995). Both English and Chinese writing systems contain various cues to pronunciation that may assist writing to sound mapping. Such correspondences were often considered to be highly consistent in English with individual letters-speech sounds matching. In Chinese, such mapping tend to be less consistent, and depend on a much larger number of orthographic elements called "phonetic radicals", which is a component of a character which forms a basic morpheme in this language.

Script specificity could also be reflected at the neural level in a study by Chen, Vaid, Bortfeld and Boas (2008) of brain regions involvement in phonological processing. They used hemodynamic measure of near-infrared spectroscopy (NIRS) to compare brain areas engaged in English and Chinese phonological processing. Results found that there was more intensive firing in the left middle frontal gyrus when individuals tried to search for phonology during Chinese processing. On the other hand, clearer activation in left superior temporal and supramarginal gyri was noticed during fine-grained phonemic processing in English reading. The results therefore supported that phonological processing may be regulated by different forms of mapping between orthography and phonology.

In an earlier Cantonese picture word interference study by Wong and Chen (2009), they segmented monosyllables with consonant + vowel + consonant (CVC) structure and found that participants' picture-naming responses were faster when the target (e.g., 星 /sing1/ "star") and the distractor shared the same CVC component (e.g., 城 /sing4/ "city"), the same CV component (e.g., 食 /sik6/, "eat"), or the same VC component (e.g., 境 /ging2/, "region"), as opposed to when they were unrelated. Also, similar facilitation effects were obtained across the CV+ tone-related and the VC+ tone-related conditions, whereas no reliable effect was found in the V+ tone-related condition. This showed significant facilitation effect was observed only when the target and distractor shared the combination of vowel and consonant, and implied phonological units that are smaller than a syllable but larger than a phoneme are important in the planning of Cantonese spoken words. This finding posed marked contrasts with related research in Western languages which indicated reliable priming effects were obtained even when the prime shared only a single segment with the target (Roelofs, 1999; Schiller, 2008).

As pointed out by Wong and Chen (2009), such discrepant results could be attributed to the effect of orthographic experiences. Dissimilar to many Western scripts, Chinese adopts a logographic writing system in which each orthographically distinct unit (character) maps directly onto a syllable, but not a phoneme. Indeed, there is evidence indicating that orthographic experience affects one’s phonological awareness (Cheung, Chen, Lai, Wong, & Hills, 2001). Consequently, the Chinese speakers might be less sensitive than English speakers to the similarity between the target and the distractor when they share only a single segment. Nevertheless drawing correlation with our current findings, the apparently absence of interference during Cantonese reading could be explained by the relatively less processing components required than in English. Comparing monosyllabic word in Cantonese and English e.g. CVC structure in 鐘 /tsʊŋ1/“clock” and /klɔk/ “clock”, reading in Cantonese would involve processing of CV + tone or VC + tone related information which entail processing of maximum of 2 unit as compared to 4 discrete phonemic units in English. Thus we hypothesize that more efficient orthographic-phonologic mapping in Cantonese could possibly contribute to reduced PI, or even result in facilitation in RT as in our results.

Besides explaining reduced phonological interference caused by language specific processing efficiency, we also explored possible phonological facilitation with respect to orthographic specificity. According to framework from Taft and colleagues, the conceptualization of lexical processing of Chinese characters includes the three subsystems of orthographic, phonologic and semantic. When a word is presented visually, the system is entered firstly through strokes and its combinations at feature level of the orthographic subsystem. Activation then can pass to the relevant phonological and semantic units which are linked at the radical and character level. Printed word frequency and regularity may therefore be part of reasons which influence the familiarity and accuracy during silent reading (Taft & Zhu 1997). We tried to delineate effects of word frequency and regularity on characters chosen in phonological related-same and unrelated negative trials in order to rule out any confounding effects in the two conditions. The total 640 trials consisted of 267 different words which 215 were found in a frequency count of a composite corpus from regional print media in Hong Kong, Taiwan and Mainland (Cheung & Chan, 1997), representing 80% coverage. The average character frequency in unrelated negative trials was 545.72 while for phonological same list trials, average frequency of 570.61 was found. Since analysis showed character frequency in phonologically same list trials were higher than those chosen in unrelated negative baseline. Orthographic familiarity may lead to facilitating effect in our present study on phonologically related same condition.

In addition to character frequency, the effect of regularity on characters presented in phonologically related-same list trials and unrelated negative trials were also examined. We hypothesize that the more regular is the relationship between phonetic radical and the whole character, less competition may exist among phonological codes activated by a given phonological radical during lexical processing to result in faster reaction time (Perfetti, Liu & Tan, 2005). Excluding simple characters, words in unrelated negative conditions and phonologically related-same list trials were categorized into regular (i.e. phonetic radical is segmentically identical to the whole character as in 指 /tsi2/ and 旨 /tsi2/), semi-regular (i.e.

phonetic compounds sharing at least the same rime as their phonetic radical e.g., 柏 /p^{h}ak3/ and 白 /pak6/), irregular, with no phonological relationship with their phonetic radical (e.g., 路 /lou6/ and 各 /kɔk3/), following the phonological relationship as highlighted in Law, Wong Yeung and Weekes (2008). We found that words composed of regular and semi-regular phonetic compounds amounted to 36.80% in unrelated negative trials, whereas in phonologically related-same list conditions, such components amounted to 40.27%. Simple characters which do not have separable phonetic components were found to be 10.00% and 13.42% in unrelated negative conditions and phonologically related-same list trials respectively. Such relatively higher regularity in the latter condition may contribute to facilitation of reaction time in phonological recall of verbal stimuli as supported by Ding, Peng and Taft (2004) and Lee, Tsai, Su, Tzeng & Hung (2005). They found that words with regular phonetic compounds have significantly shorter reading latencies than words with irregular phonetic compounds. This may possibly due to the overlapping representation of the phonetic radical that they usually also represents a stand-alone character in the orthographic lexicon (Perfetti, Liu & Tan, 2005). Such duality of representation, i.e. radical being both a part and a whole character itself may provide facilitation effect in orthographic-phonological mapping, and is differentiated from the alphabetic systems which show discrete letters and words relationship with their levels of representation non-overlapping.

Cole and Pickering (2009) studied visual and phonological similarity effect in Chinese and English users. They supported that phonologically-related words caused disturbance in naming speed and accuracy despite language specific difference between Chinese and English was not significant. In an attempt to explain the reason for non-compliance of phonological and visual similarity effect, they claimed that their Mandarin speaking participants used both visual and phonological strategies for remembering the sequences in the experiment. Visual strategies reported included remembering the ‘visual distinctiveness’ of items (features such as axis, shape and orientation), making a ‘picture story’ with items, and ‘visualizing’ or ‘reading’ items in their mind, thereby optimizing their performances in both conditions. For our experiment, though visual strategies adopted have not been testified, our orthographic structures were approximately balanced at 67.50% and 64.80% showing radicals in left-right well-formed positions in compound characters and 8.75% and 10% simple characters in phonological-same and unrelated negative trials. Since we found no equivalent radicals in probe and distractor of phonological same-list trials, disturbances due to visual similarity was not established. On the contrary, such visual distinctiveness between probes and distractors may actually facilitate the differentiating strategies during rhyme-same trials. Also sub-vocal rehearsal were observed and acknowledged by all participants in our experiment. This would likely hinder memory decay in phonological representations according to the classical multi-component WM model from Baddeley and Hitch (1974).

In conclusion, the present study has examined PI among normal Cantonese speaking undergraduates under different semantic and phonological relatedness at varying stimuli-probe distance. The results were allied with the previous English study by Hamilton and Martin (2007) showing effective inhibitory mechanism of PI when probes were related to items under semantically and phonologically related conditions in previous lists. In same list trials, normal participants with both English and Chinese backgrounds showed influences from PI in semantically related conditions. Our test however showed dichotomized results for Chinese participants in phonologically related-same list conditions which no PI was observed, but an apparent facilitation. We contributed the different outcome to language specific phonological processing mechanism in Cantonese, which manages longer units, i.e. segment between phoneme and syllable, as compared to the shorter phonemic segments in English during monosyllabic word reading. In addition, visual distinctiveness by list characters and/or increased activation due to higher frequency and regularity of characters in stimuli and probes may also enhance processing efficiency and thus result in shorter response time.

Our findings therefore not only indicated language specificity effect on inhibition of phonological PI, it also provided insights on facilitating strategies that are particular to Chinese language. However our assumptions on the mechanism of verbal inhibition could be better testified on replication to other orthographic languages and extend to structures beyond monosyllabic characters, i.e. sentences or phrases. Future related studies could be performed on brain damaged patients to substantiate clinical relevance and determine modifications required to facilitate rehabilitation. To enhance the design of the test, a-priori analysis on level of orthographic facilitation and consistency effect during orthographic-phonological mapping should also be emphasized, as they hold particular importance in Chinese language.

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* All stimuli will be presented serially

Appendix

Stimuli for inducing Proactive Interference

	List items				Probe	Response
1. Positive - Same list trials						
	蒸	攬	剖	叉	剖	"YES"
Phonetics:	/tsing1/	/lam2/	/fɐu2/	/ts^{h}a1/	/fɐu2/	
Meaning:	steam	hug	cut	fork	cut	
2. Phonologically similar - pre list						
	針	葉	風	伴	窗	"NO"
Phonetics:	/tsʌm1/	/jip9/	/fʊɳ1/	/pʊɲ6/	/tsʰœŋ1/	
	魚	襪	心	抹	心	"NO"
Phonetics:	/jyu2/	/mʌt9/	/sʌm1/	/mat8/	/sʌm1/	
3. Phonologically similar – same list						
	針	梨	油	切	心	"NO"
Phonetics:	/tsʌm1/	/lɛɪ2/	/jau4/	/ts^{h}ɪt8/	/sʌm1/	
4. Semantically similar – prelist						
	心	枱	狼	鼓	褸	"NO"
Meaning:	heart	table	wolf	drum	coat	
	鍋	餅	櫃	笑	笛	"NO"
Meaning:	pot	biscuit	shelf	smile	flute	
5. Semantically similar - same list						
	書	鼓	玉	井	笛	"NO"
Meaning:	book	drum	jade	well	flute	
6. Unrelated negative						
	鹿	雷	門	山	煲	"NO"
Phonetics:	/luk8/	/lɵi4/	/mun4/	/san1/	/bou1/	
Meaning:	deer	thunder	door	hill	pot	

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