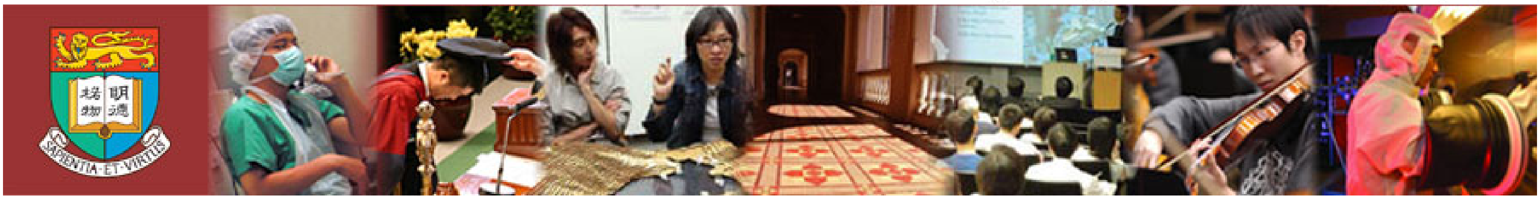

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The nature of grapheme-phoneme conversion (GPC) knowledge in Hong Kong college students

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The nature of grapheme-phoneme conversion (GPC) knowledge in Hong Kong college students

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Abstract

The nature of GPC knowledge of 40 college students from the City University of Hong Kong was studied through non-word reading task. 4 groups of stimuli with different characteristics were used to study different phenomena:1) letter strings with an embedded real word were designed to study whether the subjects were able to use the embedded real word as a sound cue, 2) letter strings that resembled real words were designed to study if the subjects could generate analogy, 3) letter strings found in local street names were used to study the effect of environmental exposure on ones' reading ability, 4) letter strings without the above characteristics were used for the sake of comparison. Results suggested that the subjects did not utilize the embedded real word as a sound cue, but they were able to generate analogy to help them read the non-words and environmental exposure was facilitative to their reading ability.

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The nature of grapheme-phoneme conversion (GPC) knowledge in Hong Kong college students

Phonological awareness is defined as the "ability to analyze spoken language into smaller component sound units and to manipulate them mentally." (Cheung, p.2). It involves the process of breaking up words into syllables, phonemes or onset and rime (Goswami & Bryant, 1990). It is well known that one's phonological awareness is closely related to one's reading ability of alphabetic scripts such as English (Huang & Hanley, 1994). A growing interest has been focused on such relationship. Cheung suggested that when a pre-reading child is confronted with a word, having the awareness that letters can be broken into smaller constituent sounds in mind, he will initially try to pronounce the letter string by using the grapheme-phoneme conversion (GPC) rules. In this sense, phonological awareness helps one's reading by facilitating the phonological recoding. Consistent with this, Goswami and Bryant argued that even when a child has just started to read, he needs to have the ability to break up a word into its onset and rime. More specifically, Gathercole, Willis and Baddeley (1991) indicated that phonological memory and awareness of rhyme are closely related to reading and vocabulary development in children. Such a relationship is understandable as an alphabetic letter represents a phoneme which "is the smallest unit of sound that can change the meaning of a word (Goswami & Bryant, 1990, p.2). "Sat" and "fat" are different in meaning as they are different in one phoneme. Therefore, when learning to read, in order to retrieve the correct word meaning, one has to understand the relationship between different collections of phonemes and different strings of letters, that is, the GPC rule (Goswami & Bryant).

However, it raises the question when one's first language (L1) is non-alphabetic such as Chinese, will one still develop phonological awareness? For Chinese orthography, the smallest pronounceable unit is character and each character corresponds to a syllable instead of a phoneme (Cheung, 1999). Over 80% of Chinese characters are complex characters that contain two radicals which are the signific and the phonetic (Cheung; Huang & Hanley, 1994; Flores d'Arcais, 1992). The former gives information on the meaning of the character while the latter gives information on the pronunciation of the word which helps encoding the pronunciation of the whole character (Ho & Bryant, 1997). Some researchers (Flores d'Arcais; Ho & Bryant) suggested that when a Chinese reader is confronted with an unfamiliar Chinese word, he may implement the strategy of reading out the phonetic radical. In this sense, there is a phonological phase in Chinese reading. Not denying the presence of this phase in Chinese reading, Huang and Hanley (1994) pointed out that only around 40% of the phonetic radicals yield a correct pronunciation. Also, unlike alphabetic systems which use a small number of elements to represent the whole system, Chinese orthography is represented by many visual symbols. It is suggested that by the age of 12, a child must have learned about 4,000 characters. Based on this, it is predicted that the ability to learn Chinese depends more on one's visual skills rather than phonological skills. In addition, Jackson, Chen, Goldsberry, Kim and Vanderwerff (1999) suggested that no phonological phase of Chinese reading is present and they hypothesized that people whose L1 is non-alphabetic such as Chinese, are not likely to develop phonological awareness and are forced to process words holistically.

Moreover, there were researchers suggesting a cross-language transfer of literacy processing skills in people learning English as second language (ESL) (eg. Akamatsu, 1999; Gottardo, Siegel, Yan & Woolley, 2001; Holm & Dodd, 1996; Huang & Hanley, 1994). Akamatsu (1999) examined the difference in the efficiency of reading aloud an English word between ESL whose L1 was non-alphabetic (Japanese and Chinese) and those whose L1 was alphabetic (Persian) by comparing the effect of distortion of a word appearance (by case alternation, i.e., cAsE aLtErNaTiOn) on word recognition in naming. It was hypothesized that if one had efficient knowledge in GPC rule, one's sensitivity to sequences of letters would be less affected by the effect of visual distortion. Results revealed that case alternation had a greater effect on ESL with non-alphabetic L1 than those with alphabetic L1. The researcher therefore suggested that when reading non-alphabetic orthography, it does not involve "computational sequential processing of the constituent letters in words" which resulted in less efficient processing of alphabetic words, and the "L1 word recognition mechanism" would be transferred to second language (L2) (p. 400).

More related to Hong Kong college students, Holm and Dodd (1996) examined the effect of L1 on L2 literacy by comparing the results of tasks that assessed phonological awareness, reading and spelling skills in English of college students from China, Hong Kong, Vietnam with ESL and students from Australia. Results showed that Hong Kong students performed more poorly than other ESL except on tasks that involved real word processing. The researchers attributed the poorer performance of Hong Kong students to their differences in the L1 literacy processing skills which is non-alphabetic. Although the L1 of both Hong Kong and Mainland Chinese is Chinese, the latter group was exposed to the alphabetic *pinyin* when they were learning to read, while the former group was not. Consequently, the former group over-relied on the "whole word strategy" when reading English though it was not the most optimal strategy.

However, one limitation of the study of Holm and Dodd (1996) is that, in the task of non-word reading, it is not clear how the non-word stimuli were chosen and created and thus no detailed information was given on where the phonological knowledge of the Hong Kong students broke down. The conclusion of Hong Kong students having "impaired ability to process non-words" was made. However, if non-words with different characteristics were given and if the Hong Kong participants performed differently across these groups of words, such conclusion might not be well justified.

The present study was an extension of the research of Holm and Dodd (1996). Non-word reading was investigated as it requires GPC knowledge and it can tap the skill that is needed when one is confronted with an unfamiliar English word in real life situation. The study mainly investigated the non-word reading ability of local college students with three research questions. The first research question was whether the phonological phase in Chinese reading (i.e. the ability of identifying a component that can guide one's pronunciation) could be transferred to reading of L2 and whether such ability could help one's reading of non-words. Based on previous findings, it was predicted that transfer of literacy skills was likely to happen and thus, Hong Kong college students would read non-words that had a real word embedded in the strings of letters better as they were able to make use of the embedded real word to guide their pronunciation. To answer this question, the accuracy of reading English non-words with and without real words embedded was compared.

The second research question was whether letter strings that resembled real words were able to help local college students to generate an analog that could facilitate their reading ability of non-words. It was predicted that the subjects would read better if the letter strings were found in real words based on the assumption that such letter strings might not require the skill of converting letters to sound by the GPC rule. Instead, they could be read by generating an analogy which had similar spelling sequences (Holm & Dodd, 1996). In this way, they actually discouraged the use of phonological strategy while encouraging the use of one's orthographic ability to determine word likeness (Gottardo, Siegel & Woolley, 2001). To answer this question, the accuracy of reading non-words with different degrees of resemblance with real words was compared.

The last research question was whether local exposure to phonetic transliteration in Hong Kong was able to enhance local college students' reading ability. The findings in Holm and Dodd (1996) that Hong Kong students performed the worst in all tasks (except real words reading) among all other ESL speakers was surprising in the sense that Hong Kong is a bilingual city, and there is English transliteration (both real words and non-words) of nearly every street name. Such transliteration was believed to be facilitative to English word reading as there is a Chinese correspondence with the pronunciation of each English non word/word. Therefore, it was predicted that the subjects would be better able to read letter strings that were found in local street or building names. This hypothesis was evaluated by comparing the accuracy of reading stimuli that contained or did not contain letter strings found in local street names.

To summarize, the present research investigated three research questions:

1) Whether the phonological phase in Chinese reading could be transferred to reading of L2 and whether such ability could help one's reading of English non-words.

2) Whether letter strings that resembled real words were able to help local college students to generate an analog that could facilitate their reading ability of non words.

3) Whether local exposure to phonetic transliteration in Hong Kong was able to enhance local college students' reading ability.

Methods

2.1 Participants

Forty subjects with the same number of males and females participated in this research. They were selected from The City University of Hong Kong. They had a mean age of 20.53 (S.D.=1.07) and the average grade they obtained in Use of English in Hong Kong Advanced-Level Examination was D (mean=4.41, S.D.=0.71, with A=1, B=2, C=3, D=4, E=5). They had to satisfy the following criteria:

1. Cantonese was their L1 while English was their L2.
2. They were undergraduates of the City University of Hong Kong

3. They have no proficient knowledge in foreign languages except Mandarin. No proficient knowledge was defined as not having enrolled in any language courses that were at advanced level.

4. They had not received systematic training of phonology, phonics or phonetics. Therefore, students of English, Linguistics and English Education were not recruited.

5. They have not studied abroad for more than one year.

2.2 Stimuli

There were four major groups of stimuli. No consonant cluster appeared in the onset of any stimuli. The first group consisted of ten non-words with an embedded real word (gp1-ERW). The first letter of the real word chosen was changed to another letter to make it a non-word (eg. farms→ sarms, pill→ yill). Therefore, the embedded real word appeared in the rime position of the stimuli. All the stimuli were monosyllabic in this group and consonant clusters appeared in the coda position.

The second group consisted of ten non-words that resembled the letter strings of real words (gp2-LSRW) (but without a real word embedded). The first letter of the real word chosen was changed to another letter to make it a non-word (eg. seed→keed, cope→ fope). Therefore, the letter strings of real words appeared in the rime of the stimuli. All the stimuli were monosyllabic in this group and consonant clusters appeared in the coda position.

In order to control for the frequency effect, the frequencies of the real words chosen in gp1-ERW and gp2-LSRW were balanced using the American English Spoken Lexicon (1999). The mean frequency of occurrence of gp1-ERW was 2778 (S.D.=1389.41) while the mean frequency of gp2-LSRW was 2770 (S.D.=1393.12). The distribution of different letters between the two groups was comparable, and also the difference between the numbers of occurrence of each letter was less than three. These measures were to make sure that any difference in performance between the two groups was attributed to the different characteristics of the stimuli instead of the difference in frequency of occurrence of the real words chosen or the distribution of letters.

The third group comprised 30 stimuli containing letter strings that were found in local streets names (gp3-LSN). There were three subgroups and each containing ten stimuli. No consonant clusters appeared in the coda position. Stimuli in the first subgroup (sub1) contained letter strings that corresponded to real words and were found in local street names (eg. topsum, manwing). The second subgroup (sub 2) comprised of one real word and one non-word which corresponded to a syllable of a street name (eg. manfung, munsum). The real word appeared in the first syllable in five stimuli and in the second syllable in the other five. The final subgroup (sub 3) contained two non-words that were local street names (eg. yipfung, loknam). The subgroups were used to find out whether the accuracy would increase with the presence of real words.

In order to control for the frequency effect, the distribution of different letters among the three sub-groups was also balanced. The difference between the numbers of occurrence of each letter in the three groups was less than three. Also, the consonant vowel (CV) structure was balanced among the three sub-groups with nine CVCCVC and one CVCCV in each group. This was to make sure that any difference in performance across the sub-groups was attributed to the effect of real words found in the stimuli.

The fourth group contained 20 non-words (gp4-NW) with the same number of monosyllabic and disyllabic stimuli. They did not resemble real words, embed any real words, and the letter strings were not found in local street names. Having no resemblance to real words meant that no real word would be formed even if any one letter was substituted. No consonant clusters appeared in the coda position.

2.3 Procedures

To determine the acceptable pronunciations for the stimuli, five English native speakers were asked to read all the non-words. Their responses were then checked by two people with phonetic training who ruled out three pronunciations as less plausible and consequently, they were not used. The others were counted as the acceptable pronunciations.

The stimuli in gp1-ERW, gp2-LSRW and gp4-NW were mixed together (block 1) while the stimuli of the three sub-groups in gp3-LSN were mixed (block 2). In order to eliminate the possible effect brought by presentation order, the order of the stimuli in both block 1 and block 2 was randomized for each subject. The presentation order of block 1 and block 2 was also counterbalanced with half of the subjects receiving block 1 first and the other half receiving block 2 first. They were not informed of the characteristics of the stimuli. Only one stimulus was presented at a time in order to reduce the effect of visual distraction.

The subjects were tested individually in one ten-minute session. The experiment was carried out in a quiet room and the whole session was audio-taped by a MP3 recorder. Before testing began, the following instruction was given. "Here are some English non words, please try your best to read them out." "呢度有 D 英文假字，請你盡量讀出佢哋讀音。" The subject was given the whole list of stimuli to study before they started reading. The other block was given right after the completion of the prior block.

2.4 Data analysis

The performance of each subject was analyzed both qualitatively and quantitatively. First, the audio-recordings were transcribed by the experimenter using IPA symbols and the percentage of accuracy of each subject's performance in different groups of stimuli was calculated. In order to answer the first research question of whether the phonological phase in Chinese reading (ie. the ability of identifying the phonetic radical to guide their pronunciation which was analogous to the ability of identifying the real word embedded in a string of letters in English) would be transferred to reading of L2 and whether such ability could help one's reading of non-words, the overall percentage of accuracy of gp1-ERW and gp4-NW for each subject was compared using paired samples t-test. Since the embedded real word appeared in the rime position of the stimuli, it was expected that the subjects could read the rimes in gp1-ERW better than those in gp 4-NW. Therefore, the percentages of errors made in rimes and onsets in both groups were compared. Qualitative analysis of error patterns was done. Each syllable was divided into onset, nucleus and coda and three types of errors (i.e. substitution, insertion and deletion) were identified in each segment. Analysis of whether the erroneous phoneme could retain the characteristics of the original target phoneme was also carried out.

For answering the second research question of whether letter strings that resembled real words were able to help them generate an analog that could facilitate their reading ability of non words, the overall percentage of accuracy of gp2-LSRW and gp4-NW for each subject was compared using paired samples t-test. Since the letter strings that resembled real words appeared in the rime position, therefore, it was expected that the subjects could read the rimes in gp2-LSRW better than those in gp 4-NW, and such hypothesis was evaluated through comparing the percentage of errors made in rimes and onsets in both groups. Error pattern analysis was also carried out in this group. The percentage of accuracy of gp1-ERW and gp2-LSRW was also compared in order to find out whether resemblance to real words was enough to help one's reading performance.

For the third question of whether local exposure to phonetic transliteration in Hong Kong was able to enhance their reading ability, the overall percentage of accuracy of gp3-LSN (this was calculated by the mean percentage of accuracy of Sub1 to Sub3 for each subject) and gp4-NW for each subject was compared using paired sample t-test. Since there were both non-words and real words in the street names, and the subjects' reading ability between these two groups might also be different, the performance among the subgroups

(Sub 1-Sub 3) was also compared using one-way ANOVA repeated measure. Since it was important to identify whether mistakes were usually made on non-words or real words, two marks were given when both words within a stimuli were correct and one mark was given if the subject got only one of the words correct. This allowed the researcher to find out whether the percentage of accuracy would increase with the presence of real words.

The responses of 4 subjects (10% of total participants) were transcribed by another university graduate with systematic phonetic training and an inter-observer reliability of 95% was obtained.

Results

3.1 Transfer of the phonological phase in Chinese reading to English non-words

Such ability was reflected through comparing the percentage of accuracy of gp1-ERW and gp4-NW using paired samples t-test. Result was significant (t (39)= 3.33, p=0.002) and the subjects scored an overall mean of 55.75% (S.D.=20.62, range: 10%-90%) in gp1-ERW and 47.88% (S.D.= 20.09, range:10%-85%) in gp4-NW. Results suggested that the subjects could read better gp1-ERW stimuli than gp4-NW. The percentage of accuracy and error rate in different segments of a syllable was calculated and the result is in table 1.

Table 1

Percentage of accuracy and error rate in different segments of a syllable

	Percentage of accuracy in gp1-ERW	Percentage of error rate in gp1-ERW	Percentage of accuracy in gp4-NW	Percentage of error rate in gp4-NW
Onset	78.00%	22.00%	95.62%	4.38%
Rime	67.25%	32.75%	59.19%	40.81%

The results suggested that subjects made more errors in rime in gp4-NW stimuli than in gp1-ERW stimuli. But errors in onsets occurred more frequently in gp1-ERW. No direct comparison was made between onset and rime as the rime contained more segments.

3.2 Effect of letter strings that resemble real words on the generation of analogy

Such effect was reflected through comparing the percentage of accuracy of gp2-LSRW and gp4-NW using paired samples t-test. Result was significant (t $(39)=4.77$, $p<0.001$) and the subjects scored an overall mean of 58.06% (S.D.=20.67, range= 11.11%-100%) in gp2-LSRW and 47.88% (S.D.= 20.09, range:10%-85%) in gp4-NW. Results suggested that the subjects found gp2-LSRW stimuli to be easier. The percentage of accuracy and error rate in different segments of a syllable was calculated and the result is shown in table 2.

Table 2

Percentage of accuracy and error rate in different segments of a syllable

	Percentage of accuracy in gp2-LSRW	Percentage of error rate in gp2-LSRW	Percentage of accuracy in gp4-NW	Percentage of error rate in gp4-NW
Onset	84.75%	15.25%	95.62%	4.38%
Rime	68.33%	31.67%	59.19%	40.81%

Results suggested that the subjects made more errors in rime in gp4-NW stimuli than in gp2-LSRW stimuli. But errors in consonant occurred more frequently in gp2-LSRW. This pattern was similar to that in the previous comparison in section 3.1.

To find out whether the embedded real word had any additional effect on the subject's reading ability when the rime of the word was similar to that of a real word, the percentage of accuracy of gp1-ERW and gp2-LSRW was compared using paired samples t-test and the result was insignificant (t $(39)=0.69$, $p>0.05$), which suggested that subjects did not find either group to be easier.

3.3 Effect of local exposure to phonetic transliteration on reading of English non-words

Such effect was revealed through comparing the percentage of accuracy of gp3-LSN and gp4-NW by paired samples t-test. Result was significant ($t(39)= 8.79$, $p<0.001$) and the subjects scored an overall mean of 79.67% (S.D.=14.92, range=43%-100%) in gp3-LSN and 47.88% (S.D.= 20.09, range:10%-85%) in gp4-NW. Results suggested that the subjects could read gp3-LSN stimuli better than gp4-NW stimuli. In order to find out whether the percentage of accuracy would increase with the presence of real word, the percentage of accuracy of the three sub-groups were compared using one-way ANOVA repeated measure. The mean for Sub 1 was 89.25 (S.D.=7.97), Sub 2 was 88.75 (S.D.=9.98) and Sub 3 was 88.00 (S.D.=12.08). The result was insignificant ($F=0.421$, $p=0.66$) which indicated that the presence of real words did not evoke any different performance in the subjects.

3.4 Analyses of Error patterns

Apart from quantitative analysis of calculating the mean percentage of accuracy for the four groups of stimuli, qualitative analyses of error patterns in different groups were also carried out. Each syllable was divided into onset, nucleus and coda and three types of errors (i.e. substitution, insertion and deletion) were identified in each segment. The distribution of different types of errors in onsets of all groups is shown in table 3.

Table 3

Percentage of occurrence of different types of errors in onsets of all groups

	Gp1-ERW	Gp2-LSRW	Gp3-LSN	Gp4- NW
Substitution	*87.50%	*90%	*75.00%	*76.92%
Insertion	7.95%	5.00%	8.33%	13.46%
Deletion	4.55%	5.00%	16.67%	9.62%

Note. Direct comparison was only possible for gp1-ERW and gp2-LSRW as the characteristics of the other groups of non-words were not comparable.

For errors in onset, substitution was the most common error type in all groups and analysis on whether the erroneous sound could retain the place and manner feature of the original target phoneme was carried out and it is shown in table 4.

Table 4

Percentage of the features of the original target phoneme that could be retained in the erroneous phoneme in the onsets of all groups

Features that were (not) retained	Examples	Gp1-ERW	Gp2-LSRW	Gp3-LSN	Gp4- NW
+place, -manner	/z/→[s]	*76.83%	*75.44%	*54.55%	*60.98%
+manner, -place	/h/→[f]	8.64%	8.77%	36.36%	17.07%
-place, -manner	/r/→[b]	13.58%	15.79%	9.09%	22.00%

Note. "+" indicated feature that was retained in the erroneous phoneme while "-" indicated feature that was not retained in the erroneous phoneme

Results suggested that the subjects showed the greatest difficulty in differentiating between different manner features in consonants. They made most errors in distinguishing between voiced and voiceless consonants (eg. zurn /z̠ɛn/→ [s̠ɛn], xook /z̠ʊk/ → [s̠ʊk]) as such error accounted for 64.92% of all the errors in manner features. However, the distribution of error was more similar for gp1-ERW and gp2-LSRW, but different for gp3-LSN and gp4-NW.

Analysis on the distribution of different types of errors in nucleus of all groups was also carried out and the result is shown in table 5.

Table 5

Percentage of occurrence of different types of errors in the nucleus of all groups

	Gp1-ERW	Gp2-LSRW	Gp3-LSN	Gp4- NW
Substitution	*91.13%	*97%	*94.15%	*88.49%
Insertion	0%	3%	5.85%	1.32%
Deletion	8.87%	0%	0%	10.20%

Note. Direct comparison was only possible for gp1-ERW and gp2-LSRW as the characteristics of the other groups of non-words were not comparable.

For errors in nucleus, substitution was the most common error type in all groups. Analysis on whether the erroneous sound could retain the features (ie. roundness of lip (R), front-back (FB) and high-low (HL)) of the original target phoneme was also carried out and the result is in table 6.

Table 6

Percentage of the features of the original target phoneme that could be retained in the erroneous phoneme in the nucleus of all groups

Features that were (not) retained	Examples	Gp1-ERW	Gp2-LSRW	Gp3-LSN	Gp4- NW
+FB, +R, -HL	/i/→ [e]	*36.11%	*55.00%	*47.24%	*51.53%
-FB, -R, -HL	/ ɛ /→ [u]	21.30%	0.00%	1.23%	6.11%
-FB, +R, +HL	/ʌ/→ [æ]	17.65%	23.00%	22.09%	24.81%
-FB, +R, -HL	/ʌ/→ [i]	12.04%	6.00%	3.07%	3.44%
+FB, -R, -HL	/ɔ/→ [ɑ]	10.19%	12.00%	12.27%	8.02%
-FB, -R, +HL	/ɔ/→ [æ]	2.78%	2.00%	1.84%	4.20%
+FB, -R, +HL	/ ɔ/→ [ʌ]	0.00%	1.00%	12.27%	1.91%

Results suggested that the subjects showed the greatest difficulty in identifying nucleus that had different high-low feature (eg. jend / dʒend/→ [dʒi:nd], jootad /dʒutæd/ → [dʒɔtæd]) and the same pattern was identified in all four groups. No bias was found towards high or low vowels.

Analysis on the distribution of different error types in codas of all groups is shown in table 7.

Table 7

Percentage of occurrence of different types of errors in codas of all groups

	Gp1-ERW	Gp2-LSRW	Gp3-LSN	Gp4- NW
Deletion	*53.45%	*45.00%	25.93%	34.48%
Substitution	24.14%	32.50%	*70.37%	26.82%
Insertion	22.41%	22.50%	3.70%	*38.70%

Note. Direct comparison was only possible for gp1-ERW and gp2-LSRW as the characteristics of the other groups of non-words were not comparable.

For errors in coda, deletion was the most common type of error in gp1-ERW (eg. jend / dʒend/ →[dʒen]) and gp2-LSRW (eg. hest / hest/ →[hes]) while substitution was the most dominant in gp 3-NSN. Among all deletion errors, 79.96% was cluster simplification. For all the substitution errors, 85.11% of the erroneous phoneme could retain the manner feature but not the place feature of the original target phoneme. Examples were pronouncing kinsung /kinsʌŋ/ as [kiŋsʌŋ] and lapbun /læpbʌn/ as [læpbʌm]. For insertion error in gp 4-NW, insertion of a vowel was the most frequent type of error and 47.42% of it happened in stimuli that ended with an 'e' (eg. koole / kul/→[kuli], zaife /zaif/→ [zaifi]). The characteristics of the stimuli were related to the different distribution of errors across the word lists and the details were included in 4.4.

3.5 Common error patterns across groups

In general, the error types in onset and nucleus were consistent in the four groups of stimuli. Substitution was the most common error type in onset and nucleus. But errors in coda were less consistent across the four groups with deletion being the most dominant error type in gp1-ERW and gp 2-LSRW while substitution was the most common in gp 3-LSN and insertion in gp 4-NW.

Common error patterns were also observed across the four groups. For onset, the subjects showed the greatest difficulty in distinguishing between voiced and voiceless consonants and fricatives were the most vulnerable to such error as 93.34% were errors made in fricatives like "z" (eg. zatch /zætʃ/→ [sætʃ]). But no occasion of voicing /s/ to [z] was found across the groups. Furthermore, the subjects usually made errors in the consonant /x/ no matter whether it appeared in the onset or coda segments as the error rate of this consonant was as high as 89.17%.

For nucleus, the subjects showed the greatest difficulty in differentiating between vowels that have different high-low features. For example, the vowels "əu", "ɔ" and "ɒ" were used interchangeably (eg. fope / fəup/ → [fɔpe], boiree / bɔiri:/ → [bəuri:]) for the vowel */o/*. The vowels "e", 'i' and "i:" were also usually mixed up for the vowel /*e*/ (eg. hest /hest/→ [h*i:*st]; deak /d*i:*k/→ [d*e*k]; lunep /lʌnep/→ [lʌnip]).

For coda, the final silent "e" was usually voiced resulting in an addition of a syllable in the coda segment (eg. koole /ku:l/→ [ku:l*i*]). Such error pattern was the most common in gp 4-NW as 18.75% of all the stimuli that contained final /e/ was voiced while only 7.5% and 10.00% was voiced in gp1-ERW and gp 2-LSNW respectively (no stimuli in gp 3-LSN ended with final /e/). Also, simplification of cluster in coda (eg. yust / jʌs*t*/→ [jʌs], jend / dʒend/→ [dʒen]) was usually observed in gp 1-ERW and gp 2-LSRW (as there were no cluster in the coda position in gp 3-LSN and gp 4-NW) and the rate of simplification was similar in these two groups (12.5% in gp 1-ERW and 10% in gp2-LSRW).

Discussion

4.1 Transfer of the phonological phase in Chinese reading to English non-words

The results of 3.1 suggest that letter strings with an embedded real word are able to help the subjects read English non-words which results in significantly higher percentage of reading accuracy than gp 4-NW stimuli. The fact that the error rate in rime of gp1-ERW was lower than that of gp 4-NW suggests that the overall higher percentage of accuracy in gp1-ERW is due to better rime reading. This may lead one to conclude that the subjects were able to identify the embedded real word in the letter strings and use it as a sound cue to help them pronounce the non-words. This is equivalent to the phonological phase in Chinese reading, in which the readers identify the phonetic radical as a sound cue to help them pronounce the whole word. In this sense, one may conclude that there is a transfer of the phonological phase in Chinese reading to English reading.

However, since the rimes of these stimuli resemble the rimes of real words, therefore, the higher percentage of accuracy may be due to the generation of analogy (the details of analogy generation and how it helps one's word reading is included in section 4.2) instead of the presence of real word. There are two possible ways for the subjects to process this group of stimuli. First, the subjects may identify the embedded real word, match the whole word with its pronunciation and blend the sound with the onset. For example, for the word 'sarms', the subject may be able to identify the word 'arms', match it with /ɑrms/ and blend it with /s/. The second possible way is generating an analogy based on the entire orthographic form, match the pronunciation with the analogy and blend the sound with the onset. For example, when seeing the word 'sarms', the subject may generate the analogy of 'farms', derive the /ɑrms/ from 'farms' and blend it with /s/.

Which reading strategy are the subjects using? With reference to the overall percentage of accuracy of gp1-ERW and gp2-LSRW, no significant difference is found using paired samples t-test. It suggests that the reading strategy for the two groups of stimuli is likely to be identical. Therefore, it is not unreasonable to conclude that the subjects use the latter strategy mentioned which shows that the subjects do not directly utilize the embedded real word as a sound cue to help them pronounce the whole word, and no transfer of the phonological phase in Chinese reading takes place when there is an alternative reading strategy, ie. the generation of analogy. Also, as the only difference between these two groups of stimuli is that a real word is embedded in the rime position in gp1-ERW, therefore, the lack of significant difference in these two groups also suggests that the presence of real words has no effect on the subject's non-word reading as long as the rimes of the words resemble the rimes of real words.

In order to investigate the efficiency of the former reading strategy mentioned above, one group of stimuli may be added in future research, ie. stimuli with an embedded real word but the rimes have no resemblance to the rimes of real words (eg. 'zaxe'). In this way, one can investigate whether the subjects utilize the embedded real word as a cue when they cannot generate analogy to help them pronounce the letter strings.

4.2 Effect of letter strings that resemble real words on the generation of analogy

The result of 3.2 suggests that letter strings that resemble real words are able to help the subjects generate analogy which results in significantly higher percentage of reading accuracy than gp 4-NW stimuli. The fact that the error rate in rime of gp2-LSRW is lower than that of gp 4-NW suggests that the overall higher percentage of accuracy in gp2-LSRW is due to better rime reading which can be facilitated by the generation of analogy. Such result is concurrent with that of Holm and Dodd (1996) which found that Hong Kong subjects performed better in stimuli with high frequency VC units, and they attributed the higher percentage to the fact that such non-words more readily elicit the use of an analogy that shared similar orthographic patterns.

The question of interest is how such non-words help Hong Kong subjects read English non-words. With reference to the possible cognitive functions in reading, one will first segment the letter strings into grapheme (Martin, Pratt, & Fraser, 2000) or onset and rime units, then code each grapheme/onset rime units by converting them into sounds and then blend the sounds together (Goswami & Bryant, 1990). But with the help of analogy, the subjects can use the sound of an already-known-word that shares similar spelling pattern (ie. rhyming words) to work out the sound of an unfamiliar word or a non-word. For example, for the stimulus 'xook', the subjects first have to segment the word into onset and rime segment, which are /x/ and /ook/. But instead of matching /o/, /o/ and /k/ to their corresponding phonemes, the subject can generate an analogy of 'cook' or 'book' and match /ʊk/ to the rime of the stimulus. In this way, the subjects do not have to match the graphemes in the rime position to their corresponding sounds and therefore, no complete phonological representations are formed. While for gp 4-NW, the subjects need a direct mapping of each grapheme to the corresponding phoneme, that is, utilizing the grapheme-phoneme-correspondence and a completely new phonological representation is formed.

Such results also suggest that Hong Kong subjects tend to process larger unit (larger than single grapheme and single phoneme) relatively more effectively when translating between spelling and sounds. The use of large-unit approach is supported by the fact that when pronouncing the stimulus 'xook' as /zʊk/, by using the analogy of 'cook' or 'book' as the cue word, the subjects match the entire spelling pattern /ook/ to the entire rime /ʊk/. Their knowledge in the words 'moon' and 'broom' has no effect on their performance on pronouncing /xook/ which can be attributed to the fact that the subjects treat the letter sequences in rime and the rime sound patterns as wholes (Treiman, Kessler, Zevin, Bick & Davis, 2006).

However, referring to the low mean percentage of accuracy of gp2-LSRW, ie. 58.06%, it suggests that this reading strategy is enough to help the subjects perform significantly better than on gp4-NW stimuli. But it is not effective enough for the subjects to achieve a high mean percentage of accuracy. As reflected in the voicing errors in onsets, it suggests that the subjects have difficulty in matching the phonemes to graphemes that are absent in their first language (L1) (the detail of this point is included in section 4.4), or they are unable to pronounce the sounds that do not exist in their L1. With reference to the errors made in rimes and the large range (11.11%-100%) in the overall percentage of accuracy, it suggests that some subjects have difficulty in generating analogy effectively. This is understandable because a prerequisite is needed in order to generate an analogy: one must possess intra-syllabic awareness. In other words, one must be sensitive to rhyme. Also, they must possess the knowledge that words that have common sounds usually share common spelling sequences and are able to form groups of words that share the same rimes (Goswami & Bryant, 1990). In this way, when they see the stimulus 'keed', with the knowledge that 'keed' rhymes with words that end with 'eed', they will easily link to words such as 'need' and 'seed' in their formed groups and such analogy is able to help them pronounce the rime. Therefore, it is reasonable that not all subjects are able to generate analogy effectively and those who can not were likely to be those who have lower intrasyllabic awareness.

4.3 Effect of local exposure to phonetic transliteration on reading of English non-words

Results of 3.3 suggest that local exposure to phonetic transliteration is helpful in English non-words reading which results in significantly higher percentage of reading accuracy than gp 4-NW stimuli. The result suggests that environmental exposure is able to help the subject's non word reading. Such result is also concurrent with that of Jackson et al (1999) who found Hong Kong subjects to be relatively more proficient in tasks that tap one's GPC knowledge than other EFL readers (Taiwan and Korea) and they attributed it to the fact that Hong Kong subjects had more extensive exposure to both spoken and written English. Holm and Dodds' conclusion about the development of subsyllabic awareness through environmental influences (eg. rhyming games) also suggested influence of environmental exposure on one's ability to use GPC.

Again, how does such group of words help the subjects' English non-word reading? Since there are both Chinese and English transliterations for every street name, one is able to derive the pronunciation of the English non-word with reference to the Chinese names even though they may not be able to make full use of the GPC rule. With constant exposure to such words, one may be able to memorize the pronunciation of the non-words and recognize them as distinctive visual patterns (Goswami & Bryant, 1990). Therefore, pronouncing such kind of non-words utilize the use of visual approach rather than the GPC knowledge and all they have to do is a direct mapping of the whole orthographic representation to the memorized pronunciation.

Comparison of the three subgroups in gp 3-LSN is made and results reveal that the presence of real words or non-words does not affect the subjects' reading ability. In fact, such finding is expected as reading both real words and non-words in this group of stimuli applies the use of visual approach as mentioned. As long as the subjects are able to recognize the orthographic patterns of the words/non-words and memorize the pronunciations of them, they should be able to pronounce them correctly. Therefore, their reading ability does not differ in reading real words and non-words. However, when compared with gp1-ERW and gp2-LSRW using one-way ANOVA repeated measure, a significant main effect was found. Post hoc analysis using LSD showed that the performance on gp3-LSN was significantly better than those on gp1-ERW and gp2-LRSW. This may be due to the fact that the items in the three word lists are not the same in terms of familiarity or difficulty to the subjects. For examples, there are no consonant clusters in the coda position in gp3-LSN and the subjects may be more familiar with this group as they have constant exposure to those letter strings. Furthermore, as mentioned, processing gp3-LSN utilizes visual approach in which no matching of phonemes to onsets takes place and little/no intra-syllabic awareness is needed as the prerequisite, but while processing gp1-ERW and gp2-LSRW, direct mapping of phonemes to onsets takes place and good intra-syllabic awareness is needed as the prerequisite in order to generate an analogy. This explains why the subjects are able to read gp3-LSN significantly better than gp1-ERW and gp2-LSRW.

4.4 Analysis of error patterns

For errors in onsets, the subjects showed the greatest difficulty in voicing feature. This may be due to the fact that voicing feature is absent in Cantonese. Instead of voicing feature, aspiration is used to distinguish between different consonants with the same place of articulation. The fact that /x/ and /z/ possessed high percentage of error rate further supports this claim as these consonants are absent in Cantonese. The subjects therefore have greater difficulty in pronouncing these consonants. This also accounts for the relatively higher percentage of errors in onset in gp1-ERW and gp2-LSRW than gp4-NW as /z/ and /x/ appear more frequently in the former groups.

For gp3-LSN, the subjects also made a number of errors in place feature and 83.33% of all errors were palatalization of /s/ to [ʃ] in the word 'so' (eg, fungso /fʊŋsəu/ → [fʊŋʃəu], hopso /hɒpsəu/→ [hɒʃəu]). This may be due to the effect of their first language. Since in Cantonese, palatalizaiton of /s/ is acceptable when the following vowel is a rounded vowel (Bauer, 1997). Therefore, the subjects may tend to palatalize /s/ in English as well when it is followed by a rounded vowel. As the frequency of /s/ being followed by a rounded vowel is higher in gp3-LSN, it explains why the subjects made relatively more errors in place feature in this group.

For errors in nucleus, mixing up /əu/, /ɔ/and /ɒ/ for the vowel /*o*/ and mixing up /e/, /i/ and /i:/ for the vowel /e/ were very common across the four groups. However, these are all possible pronunciations for the vowel /*o*/ and /e/. /*o*/ is pronounced as /əu / in the word /r**o**pe/. But it is pronounced as /ɒ/ in the words /fl**o**ck/ while it is pronounced as /ɔ/ in the word /f**o**rce/. And for /e/, it is pronounced as /e/ in the word /s**e**cond/ but /i:/ in the word /m**e**dium/ and /i/ in the word /s**e**crete/. Since the pronunciations of vowels are affected by both onset and coda (Treiman, Kessler and Bick, 2003), so when deriving the correct pronunciation, one must utilize the context-sensitive associations which suggests that one must take into account how the following and preceding consonants affect the pronunciations of the vowel. For example, */oo/* is pronounced as /ʊ/ when followed by */k/*, but it is pronounced as /u/ when followed by letters such as */m/* and */n/* (Treiman, Kessler, Zevin, Bick and Davis, 2006). It suggests that the subjects possesse certain knowledge of the vowel graphemes, however, such knowledge is not adequate for correct pronunciation of a letter string as they are not able to use context-sensitive associations when matching graphemes to phonemes. Therefore, they are able to pronounce the possible pronunciations of the vowels but they are not able to grasp the exact pronunciations.

For errors in coda, cluster simplification was the most common in gp1-ERW and gp2-LSRW. This may be because features in coda are less salient than in the front or in the middle position. Also, consonant cluster is not found in Cantonese repertoire, therefore, their ability and awareness to pronounce such feature may be lower. However, deletion was less common in gp3-LSN. This may be because as mentioned above, after constant exposure, the subjects may be able to recognize the orthographic patterns of the words in this group and memorize the pronunciations of them. Therefore, they are better able to retain the syllabic structure of the word. Also, consonant clusters are not present in this group which also explains the lower percentage of coda deletion. Referring to the substitution errors in gp3-LSN, the subjects usually made errors in place feature (eg. kinsung / ki<u>n</u>sʌŋ/→ [ki<u>ŋ</u>sʌ ŋ], kington /kiŋtʌ<u>n</u>/ →[kiŋtʌ<u>ŋ</u>) and 68.75% was due to perseveration or anticipation. For the former example, the subjects anticipate a velar nasal in the second syllable while for the latter example, the subjects persevere the velar nasal in the first syllable and these explain the relatively higher percentage of error in place feature. However, such phenomenon did not appear in the other groups. This may be because all the stimuli in gp3-LSN are disyllabic and the chance of the coda being affected by the preceding or following syllable is therefore greater. Though there are disyllabic stimuli in gp4-NW, referring to the errors due to anticipation and perseveration in gp3-LSN, the pattern is that the coda of one syllable is affected by the coda of another syllable (eg. kinsung /kin̲sʌŋ/→ [kiŋ̲sʌ ŋ]). However, referring to the disyllabic stimuli in gp4-NW, codas only appear in the second syllable (eg. jootad /dʒutæd/with /dʒ/ and /t/ being the onsets, /u/ and /æ/ being the nucleus and /d/ being the coda.), therefore, the chance of the coda being affected by anticipation or perseveration is much less in gp4-NW.

For gp4-NW, insertion is the most common as the subjects tended to voice the final silent /e/ which results in an addition of phoneme. Such error appeared more frequently in gp4-NW than gp1-ERW and gp2-LSRW. This may be due to the fact that the rimes in gp1-ERW and gp2-LSRW resemble rimes found in real words, therefore, the analogy generated is able to help their pronunciation and addition of a syllable is therefore, less frequent. However, for gp4-NW, a direct GPC is utilized and they must be sensitive to the rule of when to voice /e/ in English. As mentioned above, the subjects failed to use context-sensitive associations when matching graphemes to phonemes, therefore, they may not be sensitive enough to when to voice /e/ and this explains the frequent voicing of final /e/ in gp4-NW.

Conclusion

The present study suggests that first, local college students do not directly utilize the embedded real word as a sound cue to help them pronounce the whole word when the generation of analogy is possible and therefore, no transfer of the phonological phase in Chinese reading is found. Also, the embedded real words do not seem to provide additional help to one's non-word reading if the rimes of the words resemble that of real words. Secondly, letter strings that resemble real words are able to help local college students to generate an analog which can facilitate their reading ability of non words. But not all students are able to utilize this reading strategy effectively as it requires direct mapping of phonemes to onsets and intrasyllabic awareness. Thirdly, local exposure to phonetic transliteration in Hong Kong is able to enhance local college students' reading ability as constant exposure is able to help the subjects recognize the orthographic patterns and memorize the pronunciations of the words. Finally, the low percentage of accuracy in gp4-NW suggests that local college students possess little grapheme-phoneme conversion knowledge.

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Appendix A: Word lists used in the study

Gp1-ERW

Stimuli	Frequency of occurrence of the original word	Plausible pronunciation
sarms (farms)	4805	sɑrm
kat (bat)	2001	kæt
yill (pill)	2858	jil
kuse (fuse)	383	kjus
gup (cup)	2782	gʌp
fage (rage)	1223	feidʒ
jend (lend)	3272	dʒend
rold (bold)	2283	rəuld
xear (tear)	4637	ziə
zurn (burn)	35301	zɜn

Gp2-LSRW

Stimuli	Frequency of occurrence of the original word	Plausible pronunciation
xook (cook)	4822	zʊk
keed (seed)	2012	ki:d
yust (dust)	2865	jʌst, ju:st
bighs (sighs)	**364**	**bais (this stimulus was deleted as /big/ is real word)**
fope (cope)	2784	fəup
hest (nest)	1205	hest
deak (leak)	3241	di:k
zatch (hatch)	2271	zætʃ
mard (ward)	4613	mɑrd
bip (tip)	3523	bip

Gp3- LSN

Sub 1

Stimuli	**Plausible pronunciation**
topsum	tɒpsʌm
manwing	mænwiŋ
pinfan	pinfæn
hopso	hɒpsəu
kington	kiŋtʌn
kinsung	kinsʌŋ, kinsʊŋ
longsin	lɔŋsin
sonyam	sʌnjæm
tomhow	tɒmhaʊ
lapbun	læpbʌn

Sub 2

Stimuli	**Plausible pronunciation**
manfung	mænfʌŋ, mænfʊŋ
pinhom	pinhɔm, pinhəum, pinhɑm
sonwah	sʌnwɑ
howmong	haʊmɔŋ
kingtak	kiŋtæk
lengmat	liŋmæt
munsum	mʌnsʌm, munsʌm
wangkin	wɑŋkin, wæŋkin
kokbun	kɒkbʌn
fungso	fʌŋsəu, fʊŋsəu

Sub 3

Stimuli	Plausible pronunciation
ninpok	ninpɒk
lengtat	liŋtæt
kokming	kɒkmiŋ
wahmun	wɑmʌn , wɑmun
yipfung	jipfʌŋ, jipfʊŋ
loknam	lɒknɑm , lɒknæm
yanpo	jænpəu
lunhom	lʌnhɔm , lʌnhəum , lʌnhɑm, lunhɔm, lunhʌm
tamwang	tæmwæŋ , tɑmwɑŋ
mongsik	mɔŋsik

Gp 4-NW (monosyllabic)

Stimuli	Plausible pronunciation
zaife	zɑif
yoix	jɔiks
foac	fəuk, fɔk, fɔæk
kauce	kɔs, kaʊs
peme	pi:m, pem
nue	nju
meib	mi:b, meib
saph	sæf , sʌf
koole	kul
rez	ri:z

Gp 4-NW (disyllabic)

Stimuli	Plausible pronunciation
lunep	lʌnep, lunep
bofak	bəufæk, bɔfæk, bəufɑk
fesic	fesik, fi:sik
lautol	laʊtɔl, laʊtəul
jootad	dʒutæd
wimoz	wimɔz, wiməuz, wɑiməuz
delsom	delsʌm, delsɔm
boiree	bɔiri:
maiyit	mɑijit, meijit
gaudum	gɔdʌm, gaʊdʌm

Appendix B: Consent form

教育學院
言語及聽覺科學
Division of Speech and Hearing Sciences
Faculty of Education

香 港 大 學
THE UNIVERSITY OF HONG KONG

Informed consent form

Research topic: Where does the GPC knowledge break down in local college students

Investigators: Renee Ng Division of Speech and Hearing Sciences
University of Hong Kong

1) **Research purpose and design**

This study investigates the grapheme-phoneme-conversion (GPC) knowledge of local university students. That is, non words with different characteristics will be given to local university students to read and the percentage of correct pronunciation will be compared across different groups, which will provide information on the relationship between one's GPC knowledge and his/her mother tongue, learning and living environment. I understand that my participation will enable the researcher to better understand the local college students' ability to read non words and the factors affecting one's GPC knowledge. My involvement in the study will include a reading task of 70 non words which should take no more than 20 minutes.

2) **Enquiry about the research study**

I understand that I can enquire about further details of the study through emailing the researcher at: h0205802@hkusua.hku.hk

3) **Withdrawal and confidentiality of personal information**

I understand that my participation is on a voluntary basis. I have the right to withdraw from the study at any time. I also understand that my personal data will be kept in strict confidence.

- -

I ____________________ understand the purpose of this research project and is willing to participate in it.

Name of participant ____________________Signature ______________________Date __________

Name of witness ______________________Signature ______________________Date __________

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