

New evidence from eye-tracking on how young adult Chinese speakers process Chinese and English words when reading

Gloria Shu Mei Chwo^{1,*}

¹General Education Center, HungKuang University, Taichung, Taiwan

Abstract

Past research reveals the relevance of two routes for reading word recognition (direct/graphic and indirect/grapho-phonological). Choice of route is especially influenced by the writing system of the language, how word reading is taught, and for second languages, the first language processing route and level of second language exposure. However, the continuing effect of early instruction at a later age, and its impact relative to the other factors, have not been fully revealed. This study, therefore, examined those factors in L1 Chinese and L2/L3 English reading by university students in Hong Kong and Taiwan, exploiting the fact that early reading instruction is in both languages predominantly 'whole word' in Hong Kong versus 'phonic' in Taiwan. University participants in Hong Kong and Taiwan responded to a true/false judgment task using sentences containing contextually incongruent words that were phonologically or graphically similar to contextually congruent words. Accuracy and eye-tracking data were gathered. Only writing system effect was significant: the route favoured by the writing system prompted differential fixation time on the target word, and differential accuracy ($F= 10.94$, $p=.004$, partial eta squared=.354). The lack of enduring word reading instruction effect suggests that teachers need not limit themselves exclusively to either phonics or whole word instruction.

Keywords: L1 and L2 reading, two routes for reading, eye-tracking, writing system effect, instruction effect, awareness

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1. Introduction

The low level reading processes of written word recognition have long been a focus of attention in first language reading research, and to a lesser extent in L2 reading research. In particular, two 'routes' [1] have been posited through which a reader gets from a written word to its meaning when silently reading (which is our focus of attention). The direct route proceeds from writing to meaning by recognising the whole word shape (lexical or graphic route, GR) [2]; the indirect route proceeds via the sound, typically using sound correspondences of parts of the written word (phonological or grapho-phonological route, PR) [3] [4]. Today it is recognised that typical readers use both routes in varying degrees and with links between them at various points, depending on a range of factors [5] [6].

Associated with this, teaching methods have been designed that encourage one or the other route (whole word / 'look and say' teaching for GR, versus 'phonics' for PR) [7] [8]. The latter method might also involve using some kind of symbols representing the sounds in a more one to one way (e.g. for English the Initial Teaching Alphabet, the International Phonetic

Alphabet, the pictorial icons of Visual Phonics, or in Taiwan the Kenyon and Knott (KK) transcription system; for Chinese alphabetic Pinyin in mainland China and syllabic Zhu-Yin-Fu-Hao in Taiwan). While both approaches involve the triad of written form, sound and meaning, sound is treated as far more essential to the acquisition and process of word recognition in the second than the first. The relative merits of the two approaches have been hotly debated in the L1 context [9] although not typically based on research that measures the extent to which each route is actually used.

This is all equally relevant to L2 teaching and reading, and the purpose of the present study is to further illuminate four aspects of this balance between the GR and PR that are particularly relevant to English as a foreign language reading, and have not been so well studied. In doing so it exploits a method of data gathering that has recently gained in popularity due to its increased availability to ordinary researchers, though it is still not widely used in this research domain - eye-tracking. The core issues are: (a) whether in L1 or L2 reading the teaching method actually has any long term effect on the preferred route, in contrast with (b) the nature of the writing system of the language being read, and whether in L2 reading the preferred route is also impacted either by (c) the L1 or (d) the amount of experience of L2 reading. In effect, these issues rep-

*Corresponding author; email: schwo@hk.edu.tw

resent, in the specific domain of word reading, some of the most basic issues in SLA - i.e. the effects of instruction, L1 transfer, and L2 exposure.

2. Literature review

The way in which a person processes written words has been widely found to be influenced by the nature of the writing system of the language being read. In the early days, a large difference was expected between writing systems that directly represent the sounds of the language, such as the alphabet used for Spanish as well as, to a lesser extent, that for English, and those that only give rather weak indications of the sound, such as the logographic characters used for Chinese. The original Dual Route model [10] predicted speakers of the former employing the PR and those of the latter the GR. It soon emerged, however, that competent readers in any language use both routes [11], and that phonological processing is universally available to all readers regardless of their writing system background, which even applies to readers with Chinese as L1 [12] who can then, in fact, learn English as L2 more successfully as a result of it. Nevertheless it remains open for readers to employ different balances of reliance on PR and GR when they read, and brain research has continued to show some differences for example between processing of English and Chinese words [13].

The effect of instruction on the degree of use of this or that route has been rather less investigated. Research on phonics teaching for example documents that the PR is used in class at a conscious level as part of the phonics instruction but does not typically research how much the PR is being relied on spontaneously later in silent reading. Instead, the later measures are usually of reading comprehension or ‘word naming’ (i.e. reading a word aloud) neither of which directly reveal the extent of the reader’s reliance on the PR or GR [9]. It is of course a matter of debate how far instruction is expected to change what the learner does. It is a well-known feature of Krashen’s [14] ideas that explicit teaching of grammar does not have a lasting impact, and this would apply also to the teaching of phonics or indeed look and say word processing. Nevertheless, Scholfield and Chwo [15] demonstrated an instructional effect on word reading route preference by 12-year-olds in Taiwan and Hong Kong. In the former, phonics-type approaches are used to teach initial reading both in L1 Chinese and L2/L3 English while in the latter ‘look and say’ or ‘whole word’ is more prevalent in both. This was reflected in significantly greater use of the PR than GR in Taiwan and of the GR in Hong Kong when reading words in both languages. It is an aim of the present study to see if a similar finding will be obtained with older participants, who are much further distant from the time when they received the differential type of instruction.

When we consider reading in a language other than L1, of course the above factors affecting route preference might be supplemented by others. First, transfer of L1 route preference to L2 is a possibility, and would be more noticeable where the writing system type is very different in each language (e.g. L1 Chinese, L2 English). L1 effect on L2 decoding has indeed often been reported [16] [17]. Second, there could be an effect of extent of experience of reading in the L2. In Scholfield and Chwo [6], this produced a difference in response time regardless of the route but not a route preference. The response was faster in Hong Kong than Taiwan, which was deemed explicable from the greater role of English in daily life in the former.

All the cited studies needed in some ways to measure readers’ use of the PR and the GR. This presupposes that one can measure the route that a person uses to access word meaning from orthography when silently reading. One common approach, which we adopt, has exploited word pairs that differ in graphic and phonological similarity [15] [18]. If the GR is used, it is assumed that the reader will be more susceptible to confusion when they read words which are similar to each other in written form but not sound (e.g. English weight, height; the second character in Chinese 稻殼 and 稻穀 respectively dào qiào and dàogǔ in Pinyin). If the PR is followed then they will be more confused when they read words which are similar in sound but not written form (e.g. English write, right; second character in Chinese 公巾 and 公斤 both gōngjīn). Tasks are then devised to measure the degree of confusion. Stimuli might be graphically or phonologically similar word pairs which have to be judged for being similar or not in meaning. Alternatively sentences are created where words that make sense have been substituted by other graphically or phonologically similar words and the sentence has to be judged for truth. Response measures include time taken to respond (latency), the number of items completed in a given time, and brain activity [19] as well as secondarily the error rate of response. In the present study, the stimulus type is words in sentences as just described, and the primary response measure is eye fixation time, supplemented by the error rate in truth judgment. In our case, when participants encounter a word that does not make sense in a sentence, we are interested in whether their gaze dwells on it longer if it is similar in sound to the correct word or similar in written form.

Eye-tracking as a means of gathering data about reading in fact has quite a long history going back to the 19th century [20]. In psychology it used to require a specialist lab with burdensome equipment to be attached to the participant. Today however it has become much more widely accessible in computerised form where eye movements can be tracked without attaching anything to the participant. With respect to reading, eye-tracking has obvious advantages over

other means of researching the unconscious processes that underlie it. In particular it enables us to measure time spent looking at particular words or parts of what is read (called fixation time), not just time spent reading a whole word, or sentence etc. [21]. An assumption is made that time spent on a particular part reflects mental processing of that part and not others [22].

As Jarodzka and Brand-Gruwel [23] admit, eye-tracking is mostly used to study the low level reading process, within words and sentences. Nevertheless, we have not found any study of the two routes using eye-tracking. The closest seems to be Yip and Zhai [24] which, although not addressing the two routes, does involve Chinese and words which sound the same but have different meanings and written forms (homophones). They also included some partial homographs (e.g. shīzi: 獅子/虱子) but they were not separately examined. The authors in fact conclude by saying that it would be useful to look at homographs in parallel with homophones, which the present study does.

3. Methodology

The study has three independent variables: location of university-level participant (Hong Kong vs Taiwan); language that is read (L1/L2 Mandarin Chinese vs L2/L3 English); item interference type (graphic vs phonological similarity). Note that for many speakers in Hong Kong, Mandarin Chinese is strictly a second language after Cantonese while in Taiwan it is often a second language after Taiwanese or Hakka in terms of order of learning. The dependent variables are numbers of correct and erroneous judgments made about the truth of sentences and the eye-tracking measure of percent of time spent focused on the word that was either graphically or phonologically confusing, thus indicating preference for GR or PR. Together this design allows us to answer four questions, corresponding to the aims of the study declared at the start:

1. Is there an enduring effect of earlier instruction? The PR is encouraged in early teaching more than GR in Taiwan for both Chinese and English; the GR is favoured in Hong Kong for both languages.

2. Is there a writing system effect? The GR is favoured by Chinese, PR by English, regardless of country. Note that both places use the same traditional forms of the Chinese characters so there is no possible difference based on that.

3. Is there an L1 transfer effect of (b)? The GR would then be preferred not only for Chinese but also for English.

4. Is there an L2 exposure effect of (b)? Arguably the PR would be preferred for English more in Hong Kong than Taiwan due to greater experience of reading in English.

3.1 Participants and their background

All participants were studying at the tertiary level, through the medium of Chinese. They were volun-

teers paid to participate in this experiment. In Hong Kong, the experiment was conducted in two universities, with 13 students in Hong Kong Polytechnic University and 5 in the Hong Kong Institute of Education. After excluding unsuitable participants, only 13 participants yielded valid data. The students were studying a variety of different majors including technology, fashion design, hotel or business management, textiles and clothing, accounting, anthropology, and surveying. Their ages ranged between 18 and 20 (freshman to junior). All had been educated in Hong Kong since kindergarten.

In Taiwan, there were nine participants. Seven came from National Chin-Yi University of Technology, two others were from Feng Chia University and National Chi Nan University, respectively. Their majors included electrical engineering, management, information engineering, and computer science. Participants' ages ranged 19-20. All had been educated in Taiwan.

From further background data which we gathered, we found that all but two of the Hong Kong students claimed to have learned Chinese characters by being taught the sound of the character as a whole. Eight, however, said this was augmented by identifying the part of the character which (usually only distantly) reflected its sound. Only one mentioned use of alphabetic transcription of the sound. With respect to unknown characters while silent reading today, seven said they would just try to access the meaning of the character as a whole without accessing its sound while ten said they would try to do it via the part of the character that would be expected to reflect the sound.

From background data, all but one Taiwanese student referred to having been first taught Chinese characters via Zhu-Yin-Fu-Hao (the Taiwanese system for phonemic transcription of the sound of Chinese characters). When asked how they now dealt with a difficult character when silent reading, however, only four of the nine said they thought about the pronunciation. The rest referred to the radical, which is the part of the character that may reflect its meaning, usually obscurely.

This information then confirms what we expected about the clear difference in initial teaching of Chinese reading to Hong Kong versus Taiwanese students. However, it hints that that clear distinction may have eroded somewhat since then. In other words, Hong Kong students at their present age seem to rely somewhat more on sound, and on breaking characters into parts, than their early predominantly whole word teaching might lead us to expect. Conversely, the Taiwan students now seem to rely a little more on treating words as wholes corresponding to meaning than their early heavily graphophonological teaching would lead us to expect.

With respect to learning English reading, again the majority of Hong Kong students (11) said they originally learned the pronunciation for words as wholes,

but nine admitted to learning via letter-sound correspondences (usually along with the whole word method). When meeting an unknown English word in silent reading today, however, only seven said they would access the sound (four by a transcription of it, three as a whole word) while 11 would look at the context for the meaning (i.e. not involving sound).

For English, six Taiwanese students indicated that they first learned word reading via phonics teaching and five mentioned having first learned to read with the KK system of English phonemic symbols used in Taiwan. When meeting an unknown word in silent reading today, however, only two said they would tackle it via pronunciation. Most of the rest referred to using the context, which implies treating the word as a whole for its meaning, rather than as sounds.

Overall, then, again our expectation about participants' initial English reading teaching was largely confirmed, although there was a greater presence of phonic-type instruction reported in Hong Kong than we anticipated. In tackling words today, however, the difference between the two locations was less clear. Both seemed to have moved to a position of preferring to treat the word as a whole and focus on its meaning without regard for sound, through contextual inference.

3.2 Test Items

The experiment required a set of Chinese items and an equivalent set of English items. Each test had two practice sentences plus 120 test sentences that had to be responded to with 'true' or 'false'. The items were adopted from [15] and [25] and contained, in random order, 60 items where the correct response was 'true' and 60 where it was 'false'. In amongst the false items, there were targeted items where a word that made sense had been replaced either by one that was written visually quite differently but sounded similar (20 items phonologically similar to true items) or by one which had a similar spelling/character but sounded quite different (20 items graphically similar to true items). Thus for every item of interest, there were two control/distractor items.

Examples of English targeted items:

- phonologically similar (different spelling and meaning): Wear there is a will, there is a way
- graphically similar (different sound and meaning): On Saturday people do to the shops

3.3 Apparatus

An eye tracker eyeNTUE-180 was used to record when and for how long the eye focused on any particular part of the screen (contact time). Each image that the students saw was divided into three regions containing three parts of the sentence, plus a fourth region

that was outside the sentence. In items with graphically or phonologically confusing items, that item was always in the region labeled R1.

3.4 Questionnaire

A short open questionnaire was delivered through individual interviews which elicited background information about the participants (age, major, etc.) and asked ten questions about participants' learning and practices of word reading in each language.

3.5 Procedure

Following a small pilot study in Taiwan which resulted in some improvements to the items and their administration, the main experiment took place individually in a quiet room in the participant's university.

Participants were first asked to give their consent, then the researcher's assistants showed participants the notice on the screen, briefly explained the instructions and demonstrated how to use the interface. There were two practice items. The girls were asked to use hairpins to keep their fringe out of their faces. It was found that the dark frame of glasses would affect the computer location of the focal point. Therefore, students were asked not to wear glasses.

All the participants started with the English version followed by the Chinese. Each test item remained available for only ten seconds. Each test, therefore, took around 20 minutes. After they finished, participants responded to the questionnaire-interview individually.

3.6 Data analysis

Quantitative data were processed in SPSS. Taiwanese and Hong Kong students scored very similarly on the control/distractor items in both languages (t-tests $p > .05$), which did not contain any confusing words that were either graphically or phonologically similar to the correct word for the context. That is as expected, so supports the validity of the test we used and suggests that we had not chosen samples of participants of very different proficiency or general knowledge levels in the two locations.

4. Results

The eye-tracking results are seen in Figure 1 and Table 1.

The eye-tracking findings show, first, that on average 41-57% of the time was spent looking at the part of the stimulus sentence that contained the word that was a source of the homonymy conflict that we had designed into the items. This part then attracted almost as much attention as both the two other parts of the sentence and the off-sentence area put together. The response of participants to spend more time fixated on the problematic part than on other parts is a natural reaction and reassures us that they were reading

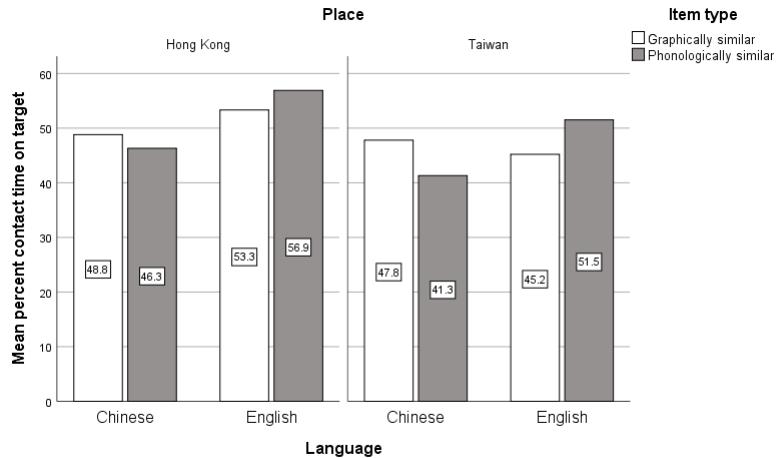


Figure 1: Responses to targeted items (percent of contact time spent on the target).

Table 1. Overall comparison of the percent of contact time spent on the target between places, languages, and item types (graphic vs phonological similarity).

Source	df	F	Sig	Partial Eta Squared
Place	1	0.93	.344	.041
Language	1	2.36	.139	.097
Language * Place	1	0.26	.616	.012
Item type	1	.01	.921	.001
Item type * Place	1	.02	.890	.001
Language * Item type	1	5.74	.026	.207
Language * Item type * Place	1	0.72	.405	.032

the items properly, with attention to extracting meaning, and hence that the task was valid. A three-way ANOVA (Table 1) shows that although the Hong Kong means are descriptively a little higher than the Taiwan means, no differences involving place are significant. The only significant effect is the language by item type interaction, regardless of place. A longer time was spent focused on graphically similar items than phonologically similar ones in Chinese, but a longer time was spent focused on phonologically similar items than graphically similar ones in English. This then appears to show a form of writing system effect. Regardless of place, the writing system that lends itself to the use of the GR (Chinese) provokes more time spent on graphic similarities. This, we presume, to reflect more noticing of the conflicts, more thought about resolving them, and, it seems from Figure 2, greater consequential accuracy of response (i.e., correct rejection of the sentences given). English, where the writing system encourages more use of the PR, provokes the opposite effect. The difference in both cases is about 5% of the total contact time (Table 2). The same pattern is broadly reflected in the accuracy findings (Figure 2), where the language by item type effect is also significant ($F= 10.94$, $p=.004$, partial eta squared=.354).

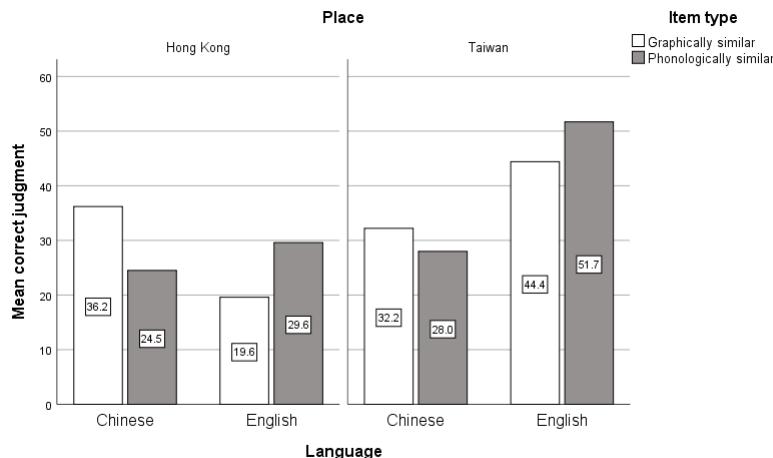
5. Discussion

We return to the possible effects that we anticipated. With respect to the instruction effect, our background data from participants reported earlier, in fact, shows that the initial instruction received many years before by the participants in both languages was, for the most part, differentiated between places as we expected, but for a slightly greater involvement of phonic teaching in Hong Kong than we anticipated. Still, it was heavily phonic in both languages in Taiwan and predominantly whole word in Hong Kong. The effect of that on processing found in younger readers in [15] was however supported neither by the eye-tracking nor correctness findings (no significant Place by Item type effects). For example, descriptively the phonologically confusable English words proved to provoke even more eye contact in Hong Kong than in Taiwan. This is against our expectation that the greater popularity of phonic teaching of word reading in Taiwan than Hong Kong would result in more eye fixation in the former where there was a latent phonologically similar word.

The reason for this lack of clear support could be that the students are of an age too removed from initial word reading instruction at primary school level for that to have a continuing effect. Hence this supports the general view of Krashen [14] that the effects of explicit instruction are short-lived. This is supported

Table 2. Interaction effect of language with item type, regardless of place (contact time)

Language	Item type	Mean	Std.Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Chinese	Graph	48.33	3.975	40.087	56.573
	Phon	43.81	2.519	38.586	49.032
English	Graph	49.26	3.852	41.265	57.244
	Phon	54.22	3.313	47.353	61.094

**Figure 2:** Responses to targeted items: correct %.

by the self-reported statements of participants about how they would handle unknown words today, where their choice was not purely reflective of the type of initial word reading instruction received in the two locations. Rather they had to some extent converged to use a more similar mix of strategies in both places and languages, approximating a balanced combination of a GR word - meaning-based approach with a PR word fragment - sound-based approach.

With respect to L1 transfer effect on the L2 word reading process, again there is no support for this from the eye-tracking (or accuracy) results. In both places, the language by item type interaction effects reflects that processing of English is significantly different from that of Chinese and does not evidence dominance of the GR as reflected in the results for Chinese. In particular, the PR is exploited far more for English than Chinese (Table 2). Thus, we instead see a writing system effect that differentiates the two languages (see below). The lack of transfer effect goes against a number of studies that have detected it such as [16] [17]. However, their designs were in many respects different, especially in that the words being decoded were not real words of the language. Hence the processing detected was not that of normal reading of familiar words.

With respect to the exposure effect, we expected students in Hong Kong, where English is traditionally a second rather than foreign language, to differ from those in Taiwan with respect to English reading. Specifically, their greater exposure and reading

experience in English might mean that the former had learned to exploit the PR more for English, and generally read English more accurately than the latter. In fact, the Hong Kong students resorted to the PR non-significantly more than the Taiwanese (Figure 1) for English but performed notably less well in accuracy (Figure 2).

Hence there is little support for Hong Kong showing a general difference or advantage due to its greater use of English in the day-to-day life of the community. A reason for this could be that the ESL advantage of Hong Kong is becoming more and more a fact of history rather than today's reality. Since Hong Kong returned to Chinese control in 1997, the role of English has been eroded there somewhat in favour of Mandarin Chinese as the standard language of the People's Republic.

By contrast, due to competitive commercial forces, the role of English in Taiwan has been boosted and, even if it still is not widely used in daily life, its status is reflected in the importance now placed on students passing proficiency exams in English regardless of their major. Taiwan ESP (English for Specific Purposes), EIL (English as an International Language), and EMI (English Mediated Instruction) are now all strongly promoted and endorsed by the Ministry of Education. The government Executive in Taiwan has launched a 2030 national blueprint for developing bilingual education. Indeed, a 2002 national survey shows that one-third of the public kindergartens and 97% of private kindergartens already provide bilingual

curriculum teaching of EIL and EFL [26].

For such reasons, the old distinction between the status of English in the two places has perhaps begun to evaporate. This is indeed supported by one Hong Kong participant who explicitly stated 'I feel my English is not good' and indeed only two of that group responded that they found it easier to read in English than in Chinese.

With respect to the writing system effect, both the eye-tracking and accuracy data support a clear significant effect of this sort. As Figures 1 and 2 show, the interpretation is supported that participants spent more time fixated on, and so presumably processing, items instantiating those conflicts that would be expected to be more noticeable when a person processes using the route favoured by the writing system: i.e., PR more than GR for English, GR more than PR for Chinese. There was, however, an unanticipated finding that greater accuracy followed longer processing time. This is intuitively quite understandable: the longer a person thinks about a homonym conflict in what they are reading the more likely they are to find the answer.

Nevertheless, the finding in some relevant past studies such as [15] and in cognitive testing in general [27] has been that slower response usually corresponds to lower accuracy. It is, however, recognised [27] that errors in the performance of cognitive tasks can arise in more than one way, involving either faster or slower times. This may be influenced by the time allowed to respond, and, associated with that, by whether conscious or only unconscious processing is involved. Kiefer and Spitzer [28] in a brain activation study confirmed that unconscious perception of words, e.g., in lexical decision tasks, involves times of only up to 200ms while conscious perception involves much longer times, albeit in similar areas of the brain. In our study, the time allowed to respond to each item was 10 seconds. Taking into account that the longest sentences used were only 13 words and that a university-level reader can read as much as 25 words in 10 seconds in a foreign language [29], this means that ample time was available for further processing of what was read at the conscious level to resolve those homonym conflicts that were noticed.

In the present case, therefore, we imagine a scenario on the lines that students of the level of our participants are reasonably proficient readers in the languages at issue and in fact make some use of both processing routes, GR and PR, in both languages. However, they tend to favour one or the other route due to the nature of the writing system employed in the item, i.e., graphic for Chinese and phonographic for English. As a consequence in our target items, they may access a similar word to the one they read, which makes more sense in the context, and their awareness is provoked [30]. In other words, they notice the conflict and pay conscious attention to it. As a result, after some thought, which accounts for the extra eye

fixation time, they realise that the word that makes more sense is nevertheless not the one written in the test item. Hence they correctly reject the sentence as untrue. That means that if the preferred processing route is graphic, due to the item being in Chinese, then scores for the graphic similarity items are higher than those for the phonological similarity items where they may have only accessed the similar item secondarily and subconsciously without their awareness being provoked, and confusion may have occurred. By contrast in studies with more limited time allowed, expenditure of relatively longer time does not result in greater accuracy because that longer time is simply not long enough to permit the conscious processing that would achieve that outcome.

Such an interpretation would be consistent with other features of the present study, in particular the older age and greater general language proficiency of participants in this study, compared with younger learners (e.g., aged 11-12 in [15]). For instance, it is known that adult learners are more able to work at the conscious metalinguistic level than pre-adults [31]. Furthermore, at a more advanced level, we may envisage that readers both in L1 and L2 would be making effective use of dual processing. In other words, even if the writing system favours graphic processing, they still also use phonological processing, though to a lesser extent, and vice versa. For more than two decades studies have attested to dual route processing in competent readers [5]. This then explains the lower but not zero scores for the disfavoured processing route.

6. Implications and Conclusion

Due to difficulty in recruiting willing participants, the sample size for this study was smaller than ideal, although eye-tracking studies traditionally can involve quite small samples (e.g., 14 participants in [32]). Still, it would be a wise precaution to treat the conclusions as suggestive rather than conclusive. Having said that, it can be argued that this study potentially has interesting implications both for research and pedagogy.

For research, it suggests that eye-tracking data can show up a dimension of processing that maybe has been neglected. That is the time spent on specific parts of the stimulus sentence that is read, something which overall response latencies cannot tell us. This reveals in our case the valuable information that when the response is correct it was more rather than less time that was spent processing the key part of the sentence.

That in turn has led us to highlight the possible role of conscious processing, which again we feel has been neglected in mainline psychological research on the two routes where research designs often try to exclude it as if it is in some way undesirable. Yet in real life reading there is usually enough time for the reader to

devote conscious attention to any problem that arises. Therefore, conscious problem solving needs to be researched alongside the subconscious processes rather than, as it usually is now, in a quite separate applied linguistic research tradition that only focuses on conscious processes, termed reading strategies, and does so using self-report instruments. In some ways, this is a paradoxical separation since in the psychological and educational tradition of reading research there has been a lot of work done on ‘phonological awareness’ and ‘morphological awareness’ as indicators of ‘reading readiness’ and wider reading abilities [33]. Yet when it comes to assessing the reading process itself the awareness dimension has often been neglected.

For pedagogy, one message of that is that awareness training has value (albeit this runs against Krashen [14], since awareness falls within the monitor which he regards as less valuable). More notably, however, the findings showed that the instructional method used for teaching initial reading, whether more graphic/lexical or phonological, does not seem to have a lasting impact on the choice of dominant processing route. Therefore, both routes are needed and whichever is highlighted in initial teaching, eventually years later proficient readers converge in all being able to operate in both routes, albeit with a preference for the route favoured by the writing system rather than the earlier teaching. Therefore, there is no benefit in the unitary positions that have been taken up in educational circles, e.g., in the UK, where one side claims that only some form of ‘phonics’ is the best initial teaching and the other that only ‘look and say’ or some extension of that such as the whole language approach is needed. Clearly, a dual approach is indicated from the start.

It does, however, emerge that the writing system has an impact on the choice of dominant route. Even within the dual teaching approach mentioned above, learners can still be prepared from the start to understand that. There is no benefit in making initial reading instruction in L1 Chinese match exactly the methods of initial reading instruction in L2 English, as has tended to happen both in Hong Kong and Taiwan. Rather, in both places, the greater emphasis in initial Chinese reading teaching needs to be on recognising the whole word and using the semantic radical, less on the phonetic part of the character and the individual sounds. For English, on the other hand, in both places the emphasis can be on highlighting phonics and KK or IPA transcription - and involve the whole word approach especially for the particular words that present few spelling clues to their sound (‘exception words’ like to, was, of).

Separately from reading, however, there remains a need in both places to teach Mandarin Chinese pronunciation for the many for whom that is a second language. Here resources like pinyin, or Zhu-Yin-Fu-Hao, could still be very useful.

References

- [1] M. Coltheart, Lexical access in simple reading tasks, in: G. Underwood (Ed.), *Strategies of information processing*, Academic Press, New York, 1978, pp. 151–216.
- [2] E. Beyersmann, M. Coltheart, A. castles, parallel processing of whole-words and morphemes in visual word recognition, *Quarterly Journal of Experimental Psychology* 65 (2012) 1798–1819, doi: 10.1080/17470218.2012.672437.
- [3] C. Perfetti, J. V. Dyke, L. Hart, The psycholinguistics of basic literacy, *Annual Review of Applied Linguistics* 21 (2001) 127–149.
- [4] V. Cook, B. Bassetti, An introduction to researching second language writing systems, in: V. Cook, B. Bassetti (Eds.), *Second language writing systems*, Multilingual Matters Ltd, UK, 2005, pp. 1–70.
- [5] J. Grainger, J. Ziegler, A dual-route approach to orthographic processing, *Frontiers in Psychology* 13 (2011).
- [6] M. Seidenberg, Reading in different writing systems: One architecture, multiple solutions, in: P. McCandle, J. Ren, O. Tzeng (Eds.), *Dyslexia across languages: Orthography and the gene-brain-behavior link*, Paul Brooke Publishing, 2011.
- [7] J. Chall, *Learning to read: The great debate*, McGraw-Hill, New York, 1983.
- [8] I. Griggs, *The teacher assistant: Four main methods learning to read*, Teaching Treasures Publications, 2000.
- [9] J. Bowers, Reconsidering the evidence that systematic phonics is more effective than alternative methods of reading instruction, *Educational Psychology Review* 32 (2020) 681–705.
- [10] K. Patterson, J. Morton, From orthography to phonology: An attempt at an old interpretation, in: K. Patterson, J. Marshall, M. Coltheart (Eds.), *Surface dyslexia*, Erlbaum, Hillsdale, NJ, 1985, pp. 335–359.
- [11] M. Coltheart, K. Rastle, C. Perry, R. Langdon, J. Ziegler, DRC: A dual route model of visual word recognition and reading aloud, *Psychological Review* 108 (1) (2001) 204–256.
- [12] K. Koda, *Insights into second language reading: A cross-linguistic approach*, Cambridge University Press, Cambridge, UK, 2004.
- [13] D. J. Bolger, C. A. Perfetti, W. Schneider, Cross-cultural effect on the brain revisited: Universal structures plus writing system variation, *Human Brain Mapping* 25 (1) (2005) 92–104.
- [14] S. Krashen, *Principles and practice in second language acquisition*, Pergamon, US, 1982.
- [15] P. Scholfield, G. S.-M. Chwo, Are the l1 and l2 word reading processes affected more by writing system or instruction?, in: V. Cook, B. Bassetti (Eds.), *Second language writing systems*, Multilingual Matters Ltd, Clevedon, UK, 2005, pp. 215–237.
- [16] M. Hamada, K. Koda, Influence of first language orthographic experience on second language decoding and word learning, *Language Learning* 58 (2008) 1–31.
- [17] E. Ijalba, L. Obler, First language grapheme-phoneme transparency effects in adult second language learning, *Reading in a Foreign Language* 27 (1) (2015) 47–70.
- [18] H.-C. Chen, J. F. Juola, Dimensions of lexical coding in chinese and english, *Memory and Cognition* 10 (1982) 216–224.
- [19] Y. Wu, Y.-K. Tsang, A. W. Wong, H.-C. Chen, The processing of homographic morphemes in chinese: an erp study language, *Cognition and Neuroscience* 32 (1) (2016) 1–15.
- [20] N. J. Wade, B. Tatler, *The moving tablet of the eye': The origins of modern eye movement research*, Oxford University Press, Oxford, 2005.
- [21] J. Ashby, K. Rayner, Literacy development: Insights from research on skilled reading, in: D. Dickinson, S. Neuman (Eds.), *Handbook of early literacy research*, Vol. 2, Guilford Press, London, 2006, pp. 52–63.
- [22] M. Just, P. Carpenter, Eye fixations and cognitive processes, *Cognitive Psychology* 8 (1976) 441–480.
- [23] H. Jarodzka, S. Brand-Gruwel, Tracking the reading eye: Towards a model of real-world reading, *Journal of Computer Assisted Learning* 33 (2017) 193–201.

[24] M. Yip, M. Zhai, Context effects and spoken word recognition of chinese: An eye-tracking study, *Cognitive Science* 42 (2018) 1134–1153, doi: 10.1111/cogs.12570.

[25] G. S.-M. Chwo, Investigating l1 and l2 reading processing difference: An exploratory comparison study between hong kong and taiwanese college students, *The International Journal of Learning* 17 (2) (2010) 233–254.

[26] I. Li, G. S.-M. Chwo, An exploration of learning environmental factors related to comprehensive english vocabulary development of preschoolers in taiwan, *Studies in the Humanities and Social Sciences (Hung Kuang University)* 19, iSSN: 1813-999X (2020).

[27] P. D. Boeck, M. Jeon, An overview of models for response times and processes in cognitive tests, *Frontiers in Psychology* 10 (2019) 102.

[28] M. Kiefer, M. Spitzer, Time course of conscious and unconscious semantic brain activation, *Cognitive Neuroscience* 11 (11) (2000) 2401–2407.

[29] G. Gorsuch, E. Taguchi, Repeated reading for developing reading fluency and reading comprehension: The case of efl learners in vietnam, *System* 36 (2008) 253–278.

[30] E. Bialystok, Aspects of linguistic awareness in reading comprehension, *Applied Psycholinguistics* 9 (2) (1988) 123–139.

[31] D. Singleton, Z. Lengyel, The age factor in second language acquisition, *Multilingual Matters*, UK, 1995.

[32] N. Smith, F. C. Glen, V. M. Mönter, D. Crabb, Using eye tracking to assess reading performance in patients with glaucoma: A within-person study, *Journal of Ophthalmology* (2014) 10.

[33] H. Zhang, L. Roberts, The role of phonological awareness and phonetic radical awareness in acquiring chinese literacy skills in learners of chinese as a second language, *System* 81 (2019) 163–178.