Effects of removing morphemic information and adding interword spacing on reading in Chinese experienced and inexperienced readers

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Writing systems of different types represent different units of language, such as phonemes in alphabetic writing systems or syllables in syllabaries. Within each type, writing systems also vary in level of phonological and morphological transparency. Some alphabetic writing systems such as Italian are almost completely phonologically transparent, while others such as English are more phonologically opaque. On the other hand, some alphabetic writing systems such as English are more morphologically transparent than others such as Italian. Furthermore, writing systems differ in their use of punctuation to represent language. Many contemporary writing systems use orthographic and typographic spaces to separate orthographic words, so that texts are written with strings of symbols separated by spacing. The orthographic convention of *interword spacing*, which has no equivalent in spoken language, is widely used, but it is not universal, and it is not used in Chinese.

The Chinese writing system represents the Chinese language (Modern Standard Chinese, or *putonghua*) by means of *hanzi*. A hanzi is a square-shaped unit composed of strokes that mostly represents a monosyllabic morpheme (a few hanzi represent submorphemic units, and 儿 represents a subsyllabic suffix). Since most Chinese morphemes are monosyllabic, and Chinese has a limited syllabic inventory of 1,300 syllables (if tones are taken into account, 400 if only segments are taken into account, Yin, 1990), one spoken syllable can correspond to many different morphemes. Because of these high levels of homophony, a syllabary or an alphabet might not the best writing systems for Chinese. Written Chinese instead represents morphemes. Chinese hanzi provide different written forms for homophonic morphemes, for instance representing the morpheme 'one' with the hanzi 一, the morpheme 'doctor' with 医, 'dress' with 衣 and so on, although they are all pronounced /i1/. This is similar to the use in English of the different spellings <flower> and <flour> for the two homophonic lexical items /flaʊə/. A hanzi can then represent one (monosemous or polysemous) morpheme (e.g., monosemous 它 /tʰa1/ 'it'; polysemous 台 /tʰaɪ2/ 'tower, platform') or two or more homophonic morphemes (e.g., 胎 /tʰaɪ2/ 'foetus', 'tyre'). Average Chinese readers know around 5,000 frequently used hanzi, while dictionaries can contain many more (almost 50,000 in the 18th century Kāngxī dictionary). Considering the hanzi to syllable ratio, each syllable corresponds on average to four frequent hanzi, and it can correspond to as many as 40 (Yin, 1990). Morpheme-based hanzi therefore appear to be a more efficient writing system for the Chinese language, compared with a phoneme-based representation such as pinyin.

Pinyin is the official romanisation system in the People's Republic of China, where it is used for teaching and reference materials, and is also the ISO (International Organization for Standardization) standard for Chinese transcriptions worldwide. It represents the phonemes of spoken Modern Standard Chinese using the letters of the roman alphabet plus four diacritics for tones. It is highly phonologically transparent, with one-to-one grapheme-phoneme and phoneme-grapheme correspondences. Chinese homophonic lexical items are not distinguished in pinyin spelling, so that for instance all /i1/ homophones ('one', 'doctor', 'dress', etc.) are spelled yī. This is similar to English /pɑːm/ 'a part of the hand' and 'a tree' being both spelled <palm>, but on a much larger scale. Hanzi and pinyin are therefore written representations of the same

language, but can be placed at the two extremes of the phonological and morphological continua. Hanzi are morphologically transparent, while also conveying some phonological information at the syllabic level; pinyin is highly phonologically transparent at the phonemic level but provides no morphemic information.

As discussed above, homophonic morphemes are represented with different hanzi, but they are all homographs in pinyin transcriptions. This leads to high levels of homophony in pinyin texts if pinyin is written with spacing between syllables, to reflect the spacing conventions of hanzi.

In order to disambiguate homophonic morpheme transcriptions, pinyin syllables are grouped into orthographic words composed of one or more syllable. Pinyin, in line with other alphabetic writing systems, uses interword spacing, with most orthographic words being composed of one or two syllables. This is generally considered useful to reduce the effects of the high number of Chinese homophones (Duanmu, 2001), which in pinyin transcriptions are also homographs. For instance, in the pinyin sentence '*diàn shì zhèng zài bō sòng xīn wén*' (the television is broadcasting the news), each syllable corresponds to a large number of homophonic morphemes, whereas if the sentence is written in word units, for example, '*diànshì zhèngzài bōsòng xīnwén*', three out of four words have no homophones. When syllables are grouped together in orthographic words, pinyin materials should be easier to read because there are fewer homophonic polysyllabic lexical items than monosyllabic morphemes. Statistics vary across researchers, but the percentage of Chinese words that have homophones is much lower than for hanzi (e.g., 7% in Zhou, 1987, 12% in Wen, 1980, quoted in Hannas, 1997).

Although pinyin is officially written with interword spacing (International Organization for Standardization, 1991), the conventions determining word segmentation are not always clear or consistent. Chinese word segmentation is a complex task, and both Chinese laypersons (Author, 2005) and linguists (Duanmu, 1998) generally disagree on the placement of interword spacing in Chinese texts, while speakers of Chinese as a Second Language generally rely on the orthographic word segmentation conventions of their first language (Author, 2005, 2007).

Effects of linguistic information on Chinese reading

Differences among writing systems can result in different reading and spelling processes among users of diverse writing systems. Overall, the reading speed of experienced readers of different writing systems is comparable. For example, it takes the same time for Chinese and English readers to read the same text in their respective languages (Sun, 1993). Still, reading processes may differ.

Chinese hanzi provide both phonological and morphemic information (the latter is also called 'semantic information', but in this paper the term 'morphemic' is preferred, on the assumption that written language units represent language units). Much research on Chinese reading has concentrated on the recognition of hanzi in isolation. There is disagreement about the time course of phonological versus semantic activation, as it is unclear which one is activated earlier, with some studies finding evidence indicating earlier phonological than semantic activation (e.g., Perfetti & Tan, 1998) and others finding the opposite (Zhou & Marslen-Wilson, 2000). It is also unclear to what extent homophony affects Chinese readers compared with English readers (Treiman, Baron, & Luk, 1981). While this line of research has concentrated on the recognition of single hanzi or two-hanzi words, an important related question is what role morphemic information plays in the reading of texts.

Since both morphological and phonological processing are involved in hanzi reading, the question is what happens when morphological information is removed. An answer can come from studies that compare hanzi reading with pinyin reading. Evidence shows that Chinese adults and school children alike are much slower in reading pinyin (romanised Chinese) materials compared with hanzi materials. Almost 20 years ago, Sun (1993) found longer fixation durations and slower reading rates with pinyin than hanzi versions of primary school texts, with adults reading hanzi four times faster than pinyin, and primary school children reading hanzi 2.5 times faster than pinyin. The study also reports a non-significant decrease in pinyin reading rates with increasing level of education, from primary school to high school to university students. It is likely that adults were less familiar with pinyin twenty years ago than they are now, partly because of changes in education and partly because of the spread of technologies that require pinyin reading and writing, such as computers and mobile phones. Still, in a more recent fMRI study of hanzi and pinyin reading (Fu, Chen, Smith, Iversen, & Matthews, 2002), presentation speed had to be three times slower for pinyin than for hanzi materials, to accommodate participants' slower reading speed as revealed in a pilot experiment.

The slowness in the reading of pinyin is generally attributed to lack of familiarity and practice (Fu et al., 2002; Sun, 1993). It has also been attributed to the high numbers of homophones that are disambiguated by hanzi but not by pinyin (Sun, 1993), and to pinyin requiring an assembled procedure, slower than the addressed procedure used with hanzi (Fu et al., 2002). However, it is possible that pinyin is read slowly because it does not provide morphemic information; this is the traditional Chinese view and it has been argued for instance by Sun (1993). Interestingly, there is some evidence that English-speaking learners of Chinese as a Second Language read pinyin faster than hanzi (Light, 1976). Author (2009) found that English learners of Chinese read pinyin sentences more than 1.5 times faster than Chinese native readers, and suggested that this could be due to English learners' higher levels of exposure to pinyin in particular and the roman alphabet in general, but could also be because Chinese native readers need morphemic information in order to read Chinese, whereas English learners of Chinese are used to reading a phonological first language writing system and therefore are not disrupted when morphemic information is removed from L2 Chinese reading materials.

In order to test the importance of morphological information in Chinese reading, it is then possible to compare hanzi reading and pinyin reading, but limited experience in pinyin reading is a confounding variable, as slow reading of pinyin could be due to lack of experience with the script, rather than to characteristics of the script. A solution is to test primary school children. While adults might not be used to pinyin reading, primary school children are more exposed to pinyin than to characters in the early years of education. In the first semester of school, children spend 38% of instructional time in learning pinyin (Wu, Li, Shu, Anderson, & Li, 2002). Yan, Miller, Li, & Shu (2008) analysed a widely-used primary school textbook series and found that in the first semester all materials are written in pinyin, then until the end of the second year materials are written with pinyin above all hanzi. Afterwards, pinyin is only used for new hanzi. Therefore, Chinese children in the early stages of reading have extensive exposure to pinyin. If these children read pinyin more slowly than hanzi, this should be due to characteristics of the script itself, rather than to levels of familiarity with the script.

Effects of interword spacing on Chinese reading

Interword spacing plays an important role for English readers. In studies where interword spacing has been removed, English adult readers have exhibited a decrease in reading rate of between 30% (Epelboim, Booth, & Steinman, 1994) and 50% (Pollatsek & Rayner, 1982). It is possible that in readers of word-spaced writing systems interword spacing guides saccadic movements, and/or that it facilitates word recognition. Still, interword spacing does not facilitate readers of writing systems that do not mark word boundaries. It increases reading rate in adult Thai readers only for scrambled, but not normal, texts (Kohsom & Gobet, 1997); and in adult Japanese readers, only for texts where kanji have been replaced with kana (syllabic graphemes), but not for normal kanji-and-kana texts (Sainio, Jukka, Bingushi, & Bertram, 2007).

With regard to Chinese readers, interword spacing does not appear to affect normal reading. It does not increase Chinese readers' reading rate for sentences, whether presented tachistoscopically (Liu, Yeh, Wang, & Chang, 1974) or on screen (Bai, Liversedge, Zang, & Rayner, 2008; Inhoff, Liu, Wang, & Fu, 1997). Although Bai et al. found faster reading with interword spacing, this probably happened because hanzi-spaced sentences occupied twice the width on screen compared with word-spaced sentences. Chinese readers do not simply ignore spacing: random spacing results in slower reading rate and different eye movement patterns in Chinese adults and children (Bai et al., 2008; Shen et al., 2010). Furthermore, interword spacing facilitates Chinese reading under unusual circumstances, for instance reading ambiguous sentences without context (Hsu & Huang, 2000a), reading moving texts on single-line displays (Shieh, Hsu, & Liu, 2005), or possibly reading highly complex texts (Hsu & Huang, 2000b). Since interword spacing only helps Chinese readers dealing with unusual requirements, it seems to play the same facilitatory role as phrase or clause chunking for English readers (Bever, Jandreau, Burwell, Kaplan, & Zaenen, 1991; Hartley, 1993; Keenan, 1984). Even when reading romanised Chinese, which is normally word-spaced, Chinese native readers are not disrupted when interword spacing is replaced with intersyllable spacing, either in reading rate and comprehension of sentences (Author, 2009) or in comprehension of texts (King, 1983).

Interword spacing appears not to facilitate Chinese reading, and possibly not even when Chinese is written in pinyin, which is normally word-spaced. Still, all the evidence above is based on studies of experienced readers. English native-reading readers of Chinese as a Second Language are disrupted when interword spacing is replaced by intersyllable spacing in pinyin sentences (Author, 2009). With hanzi materials, they are not facilitated by interword spacing when reading sentences (Author, 2009), and they may even show disruption when reading simple materials both in terms of eye movements (Everson, 1986) and in reading rate (Yao, 2011). While interword spacing facilitates the reading of texts of relative complexity, its positive effects are negatively correlated with L2 reading proficiency (Author & Lu, 2011). It appears that interword spacing does not facilitate experienced Chinese native readers reading normal texts, but it facilitates L1-English readers of L2-Chinese whose L2 reading proficiency is below the threshold that allows them to behave like native readers. The question is then whether interword spacing facilitates English readers of Chinese because of their word-spaced L1 writing system, or whether it can also facilitate inexperienced Chinese native readers, such as primary school children. Previous research found no facilitative effects in children reading hanzi materials (Shen et al., 2010), but no research has looked at pinyin materials.

The present study

The present study examined the effect of replacing morphemic information with phonemic information and of adding interword spacing on Chinese reading. By comparing experienced and inexperienced readers, and by examining the interaction between type of linguistic information and interword spacing, it may be possible to uncover why hanzi sentences are read faster than pinyin sentences.

Two experiments compared reading rate and comprehension of Chinese sentences written with either morphemic or phonemic information (hanzi or pinyin), and with either interword or inter-morpheme spacing. The first experiment tested experienced readers (university students), the second tested inexperienced readers (primary school children).

We predicted that readers would be disrupted when only phonemic information is provided, because morphemic information plays an important role in reading Chinese. Still, the disruption could be entirely or partially caused by lack of experience in reading pinyin, rather than by the type of linguistic information provided. The second experiment then tests primary school children, who are not experienced at hanzi recognition and are exposed to pinyin frequently. If the children are slower at reading pinyin, this disruption cannot be explained as a consequence of little practice with pinyin, and therefore the likely main cause of the disruption would be the absence of morphemic information.

With regard to interword spacing, it has been found that this does not facilitate Chinese readers reading either hanzi or pinyin material, except ambiguous or very complex materials. This indicates that interword spacing is not a universal facilitator of reading. It does not even facilitate Chinese readers' reading of pinyin, although their reading proficiency is low and pinyin is normally written with interword spacing. Still, it facilitates reading in English readers of Chinese as a Second Language when reading pinyin simple sentences and hanzi complex texts. This could be due either to low reading proficiency, or to the effect of a word-spaced first language writing system on second language reading. If interword spacing facilitates reading in inexperienced readers, regardless of the writing system involved, then Chinese schoolchildren should show facilitation for interword spacing both when reading hanzi and when reading pinyin, and Chinese adults when reading pinyin. If interword spacing facilitates reading in children when reading pinyin but not when reading hanzi, then it is possible that it facilitates the reading of inexperienced readers of alphabetic writing systems. If interword spacing does not facilitate Chinese children's reading of either hanzi or pinyin materials, then it is possible that it only facilitates reading for those whose first language writing system is word-spaced.

By combining manipulations of type of linguistic information and type of spacing, and by testing adults and children, the study aims to explain why romanised Chinese is read more slowly than hanzi, by ruling out some of the explanations put forward in previous research. As noted earlier, the most widely proposed explanation is that Chinese readers are not experienced at reading pinyin (Fu et al., 2002; Sun, 1993). Since Chinese primary school students are unproficient hanzi readers and are much exposed to pinyin, if child participants in this study read hanzi faster than pinyin this would indicate that the effects of type of linguistic information are not due to lower levels of pinyin reading proficiency, or at least not entirely due to this reason. Another explanation has been that pinyin has high numbers of homophones (Sun, 1993). In the present study, interword spacing has been used to almost completely eliminate the issue of homophones, because pinyin syllables have large numbers of homophones, but

pinyin orthographic words have no or very few homophones. If participants read word-spaced pinyin sentences slowly, this cannot be due to problems with homophony. If pinyin is read more slowly than hanzi both by adults and by children, both with intersyllable spacing and with interword spacing, then the most likely explanation would be that hanzi are read faster than pinyin because they provide morphemic information.

Experiment 1: Effects of type of information and spacing on reading in Chinese experienced readers

This experiment examined the effect of phonemic versus morphemic information and interword versus inter-morpheme spacing on sentence reading in Chinese experienced readers.

Design

A 2 x 2 repeated-measures design was used to test the effect of linguistic information (morphemic; phonemic) and type of spacing (interword; inter-morpheme) on reading in Chinese experienced readers. The dependent variables were reading rate (number of syllables per second), and percentage of correct responses in a sentence-picture verification task.

Participants

Twenty-four Chinese final-year university students were recruited from the English department of a prestigious university in China. There were 13 females and 11 males, aged between 21 and 22, with normal or corrected-to-normal vision. Chinese students of that age are all familiar with the roman alphabet and interword spacing because they learnt pinyin in primary school, and through exposure to written English. Participants had studied English on average for 10 years, they were majoring in English, and they rated their English proficiency as 5 or 6 on a 7-point scale where 7 was 'native-like'.

Task, materials and procedure

A sentence-picture verification task was employed as the experimental task. The sentences were written with morphemic or phonemic information, and with interword or inter-morpheme spacing. The task, materials and procedure were the same as in Author (2009).

Experimental trials consisted of the presentation of a black-and-white line-drawn picture with a written sentence. The picture was presented on a computer screen for 1000 msecs, and then a sentence appeared underneath. Participants were asked to decide whether the sentence matched the picture or not. The presentation duration of the picture was long enough to ensure picture recognition processes were completed before the sentence was presented (the presentation duration of the picture prior to presentation of the sentence was equivalent to the length of time needed to name the

picture in one's native language as shown in previous studies, see, e.g., Vigliocco, Vinson, Lewis and Garrett, 2004). Once the sentence was presented under the picture both picture and sentence remained on the screen until the participant responded. There was then an interval of 1000 msecs before the presentation of the next trial. Participants indicated whether the sentence matched the picture or not by pressing one of two buttons on a response box (right-hand button for a YES response and left-hand button for a NO response). There were forty-two experimental trials, preceded by four practice trials. The pictures represented objects and actions, selected from the naming battery of Druks and Masterson (2000). Sentences were eight syllables long, therefore in the hanzi condition there were eight hanzi, in the pinyin condition the mean length was 26.4 letters (*SD* = 2.48). Sentences were structurally and lexically simple. Half of the sentences matched the picture and half did not (an example of a NO trial involved the presentation of a picture of an empty desk with the sentence 'on the desk there is a computer').

For each picture, four sentences were prepared, by varying type of linguistic information (morphemic, i.e., hanzi; or phonemic, i.e., pinyin) and type of spacing (interword or inter-morpheme). In the interword spacing condition pinyin syllables or hanzi were grouped in orthographic words preceded and followed by spacing; in the inter-morpheme spacing condition, all pinyin syllables or hanzi were preceded and followed by spacing. For each sentence, the interword and inter-morpheme versions occupied the same width on the screen. The following example shows the four versions of the sentence for which the translation is 'On the desk there is [a] computer':

桌 字 上 放 着 计 算 机 。 [Morphemic, inter-morpheme spacing condition]
桌 字 上 放着 计算机。 [Morphemic, interword spacing condition]
Zhuō zi shàng fàng zhe jì suàn jï. [Phonemic, inter-morpheme spacing condition]
Zhuōzi shàng fàngzhe jìsuànjï. [Phonemic, interword spacing condition]

All participants saw half of the sentences written in hanzi and half written in pinyin: half of them read the first 21 sentences in pinyin followed by the next 21 written in hanzi, while the other half read the first 21 sentences in hanzi and the next 21 in pinyin. Within each block, sentences appeared on the screen in the same order for all participants, but the software randomly allocated each sentence to the interword or inter-morpheme spacing condition. Participants were asked to read the sentences silently and to decide whether the sentence matched the picture as quickly as possible, while avoiding errors, by pressing one of the two buttons on the sides of the response box. The task was programmed using the PsyScope X software and administered on a PowerBook MacIntosh laptop computer. Stimulus presentation and recording of responses were managed by PsyScope X, and timing was measured by means of an IoLab Response Box that interfaced with the computer.

Following the sentence-picture verification task, participants were asked whether reading was easier with hanzi or pinyin materials, and with or without spaces between words, and were asked to explain why. This was intended to provide qualitative data about Chinese readers' experiences with the presentation formats.

Results

Response times for incorrect responses, and those more than 3 standard deviations above or below the mean for each participant, were eliminated prior to analysis of the data; a defective item was also eliminated. The correlation between response times and

errors was not significant ($r = .09$, $p = .68$), indicating that participants were not trading accuracy for speed.

Table 1 shows mean reading rate (in syllables per second, sps) and percentage of correct responses by type of linguistic information (morphemic, phonemic) and type of spacing (interword; inter-morpheme).

The absence of morphemic information resulted in slower reading rates; participants read pinyin sentences almost three times more slowly than hanzi sentences ($M = 1.88$ sps, $SD = 0.33$ vs. $M = 5.34$ sps, $SD = 1.65$). With regard to error rate, participants performed almost at ceiling level, with mean percentages of correct responses being 98.22% and 96.23% for pinyin and hanzi sentences respectively.

Interword spacing slowed down reading rates for hanzi sentences (by 0.4 sps on average) but not for pinyin sentences. It did not affect error rate, as can be seen in Table 1.

Table 1: Mean reading rate and percentage of correct responses by type of linguistic information and type of spacing for adult readers in Experiment 1 (standard deviations are in brackets)

Linguistic Information	Reading Rate (syllables/sec)		Correct Responses (percent)	
	Morpheme	Word	Morpheme	Word
Morphemic (hanzi)	5.54 (1.80)	5.14 (1.58)	97.22 (3.42)	95.24 (5.06)
Phonemic (pinyin)	1.89 (0.37)	1.87 (0.31)	98.31 (2.89)	98.12 (2.87)

Separate 2 x 2 repeated-measures ANOVAs were performed on the reading rate and accuracy data to analyse the effects of linguistic information (morphemic; phonemic) and type of spacing (inter-word; inter-morpheme).

The ANOVA for reading rate revealed a significant main effect of linguistic information and a large effect size ($F(1, 23) = 112.53$, $p <.001$, partial $\eta^2 = .83$): Chinese readers read faster when morphemic information was provided, compared with phonemic information. The main effect of type of spacing ($F(1, 23) = 7.61$, $p = .011$, partial $\eta^2 = .25$) was qualified by an interaction, although the effect was weak ($F(1, 23) = 4.62$, $p = .042$, partial $\eta^2 = .17$). The effect of spacing was not significant for pinyin ($t(23) = .65$, ns), but with hanzi participants were slower with inter-word spacing ($t(23) = 2.48$; $p = .021$, $r = .46$).

To further investigate the nature of the effect of type of spacing, following the advice of an anonymous reviewer, we tested whether order of presentation (pinyin before hanzi or vice versa) interacted with type of spacing in affecting hanzi reading rate. An interword spacing effect was calculated by subtracting the reading rate with inter-morpheme spacing from the reading rate with interword spacing. Descriptively, interword spacing slowed down readers in the second block of trials more than in the first, regardless of which type of materials they saw first. When reading hanzi

sentences, interword spacing slowed down the group that read hanzi after pinyin materials by 0.77 syllables per second ($SD = 0.82$), whereas the group that read hanzi first was not slowed down ($M = 0.03$ sps, $SD = 0.60$). With pinyin materials, interword spacing slowed down those who saw pinyin after hanzi by 0.10 syllables per second ($SD = 0.16$), but did not slow down those who saw pinyin first ($M = 0.05$, $SD = 0.16$).

A 2 x 2 mixed ANOVA with order of presentation (pinyin first; hanzi first) as a between-group variable and type of linguistic information (pinyin, hanzi) as a within-group variable was conducted on the interword spacing effect. There was a main effect of type of linguistic information with a small effect size ($F(1, 22) = 6.07$, $p = .022$, partial $\eta^2 = .22$): the interword spacing effect was stronger with hanzi than pinyin materials. The main effect of order of presentation approached but did not reach significance ($F(1, 22) = 4.27$, $p = .051$, partial $\eta^2 = .16$). Critically, the interaction was significant ($F(1, 22) = 2.35$, $p = .009$, partial $\eta^2 = .27$): interword spacing slowed down hanzi reading more in those who saw hanzi after pinyin sentences than in those who saw hanzi before pinyin ($t(22) = 2.54$, $p = .019$, $r = 0.41$).

Turning to the analysis of the accuracy results, the 2 x 2 ANOVA was conducted on rank-transformed data due to skewedness. The analysis revealed no significant effect of either linguistic information or type of spacing, and neither was the interaction significant (all $Fs < 1$).

There was large individual variation in the effects of interword spacing on pinyin reading rate. Interword spacing slowed down 50% of participants (ranging from 0.03 to 0.37 sps slower than with inter-morpheme spacing), and increased reading rate in 46% (ranging from 0.04 to 0.31 sps faster; one participant read at the same rate in both conditions). To test whether interword spacing facilitated less proficient readers, the interword spacing effect was entered in a correlation analysis with pinyin reading rate, which was considered a measure of pinyin reading proficiency, and calculated as the mean pinyin reading rate across presentation conditions. The interword spacing effect was not significantly related to pinyin reading rate ($r = 0.34$, $p = .107$), indicating that interword spacing did not facilitate the reading of less proficient readers of pinyin more than that of more proficient readers.

Further analyses were carried out to test whether sentence-picture concordance modulated the effect of interword spacing, that is, whether interword spacing affected hanzi and pinyin reading differently for YES and NO responses. In the original design, differences between YES and NO answers were controlled because for each condition half of the answers were YES and half NO, thanks to random assignment of the spacing condition. The hypothesis tested in this ancillary analysis, suggested by a reviewer of a previous paper, was not planned in the original study design, and it was therefore not entered in the main analysis above. The results are plotted in Figure 1.

Figure 1: Mean reading rates (syllables per second) for pinyin and hanzi sentences according to sentence-picture concordance (YES responses; NO responses) and type of spacing (interword; inter-morpheme) in adult readers in Experiment 1
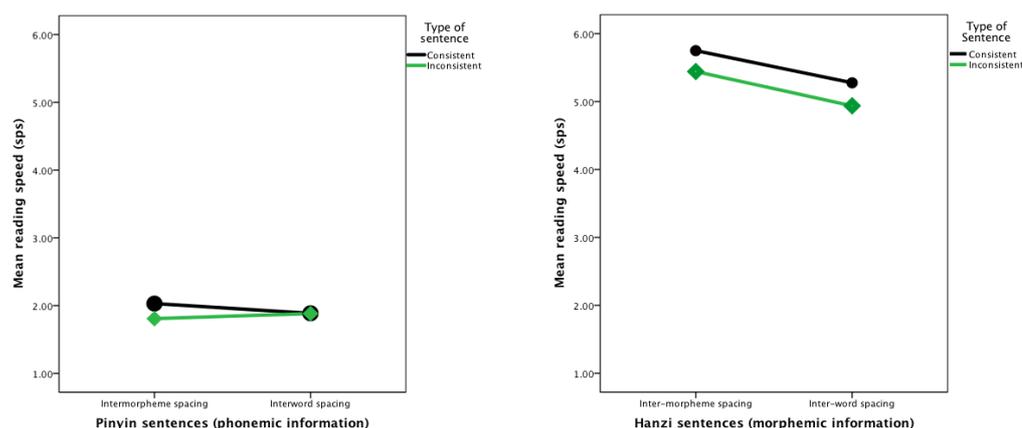
Separate 2 x 2 repeated-measures ANOVAs were conducted on the reading rate data for pinyin sentences and hanzi sentences, to test the effect of sentence-picture concordance (consistent; inconsistent) and type of spacing (interword; inter-morpheme). For pinyin sentences the main effect of sentence-picture concordance was not significant ($F(1, 23) = 3.54$, $p = .072$, partial $\eta^2 = .13$), and neither was that of type of spacing ($F(1, 23) = 1.33$, $p = .261$, partial $\eta^2 = .06$). There was a significant interaction of concordance and type of spacing ($F(1, 23) = 5.11$, $p = .034$, partial $\eta^2 = .18$): reading rate was slower with interword spacing than with inter-morpheme spacing only when the sentence matched the picture ($t(23) = -2.35$; $p = .028$, $r = .44$); when the sentence did not match the picture the effect of type of spacing was not significant ($t(23) = 1.45$; $p = .161$).

With hanzi sentences there was a main effect of type of spacing ($F(1, 23) = 8.17$, $p = .009$, partial $\eta^2 = .26$): reading rate was significantly slower with interword spacing than inter-morpheme spacing for both consistent and inconsistent sentences. The main effect of sentence-picture concordance approached but did not reach significance ($F(1, 23) = 4.11$, $p = .054$, partial $\eta^2 = .15$). The interaction was not significant ($F(1, 23) = 0.02$, $p = .892$, partial $\eta^2 < .01$).

Participants' answers to questions about the relative difficulty of reading hanzi or pinyin with or without interword spacing largely confirmed the quantitative results. All respondents ($N = 18$; 6 participants did not provide valid answers) stated that reading hanzi is easier than reading pinyin. Among those who explained the reason(s) ($N = 14$), 71% stated that hanzi give direct access to meaning or that pinyin needs to be matched to the corresponding hanzi; 36% mentioned lack of practice in reading pinyin, 29% stated that sounding out pinyin takes time, and one participant mentioned homophones. Responses included: "I see it [a hanzi] and I just know the meaning"; "when I see the hanzi I directly know the meaning, but when I see the pinyin I have to first translate it into sound, and from the sound I get the Chinese reading. I cannot get the meaning from the pinyin characters, so it needs a process of translation". With regard to the effect of interword spacing, participants' responses were mixed. With hanzi materials, 60% of participants said that interword spacing had no effects; the remaining 40% believed it had an effect, but 13% considered it positive and 27% negative. Three participants explained the perceived negative effects of interword spacing: two said that it makes the readers' eyes travel farther, one said that it can be confusing. With pinyin materials, two thirds of respondents considered interword spacing useful, while about one third believed it had no consequences ($N = 10$ and 4, respectively; 1 respondent considered it negative). Reasons for considering interword spacing useful were: it provides help in

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identifying words or phrases ($N = 5$), it makes meaning clearer ($N = 2$), and familiarity with word-spaced pinyin ($N = 1$).

Discussion

Results confirm the experimental hypothesis that replacing morphemic information with phonemic information negatively affects Chinese readers. Chinese university students read more than 3 times more slowly with pinyin than with hanzi materials. This confirms previous findings that pinyin is read three or four times more slowly than hanzi (Author, 2009; Fu et al., 2002; Sun, 1993).

The results also indicate that adding interword spacing does not facilitate hanzi reading, and indeed negatively affects hanzi reading rate. Interword spacing slowed down participants by as much as 24 hanzi per minute on average. While the lack of a facilitative effect had been shown before (Bai et al., 2008; Author, 2009; Inhoff et al., 1997; Liu et al., 1974), negative effects of interword spacing had so far only been found in advanced second language readers of Chinese (Everson, 1986; Yao, 2011), but not with native readers. The reason for this negative effect is unclear, but it could be due to two factors. First, the negative effect was more evident in the second than in the first block of trials, and with hanzi materials when participants had seen pinyin materials before. It is possible therefore that interword spacing has negative effects when Chinese readers have been primed to notice it. The priming effect may be stronger when the first set of stimuli is in romanised Chinese, both because pinyin is normally written with interword spacing and because interword spacing in pinyin is more obviously visible as it separates long strings of letters. Interword spacing may be less noticeable in hanzi materials, since with such materials it is not generally used, it only separates strings of one or two symbols, and because variable width of spacing is commonly used with hanzi texts to allow for justification.

A second reason for the negative effect of interword spacing found in the present study could be that participants were experienced and proficient readers of English, at the end of a major in English at one of the most prestigious Chinese universities. It is possible that these biliterates are affected by interword spacing more than Chinese readers who have limited knowledge and experience of reading English. Bai et al. (2008) argued that the lack of facilitative effects of interword spacing is due to the presence of opposite forces: on the one hand, interword spacing speeds up reading because it facilitates word recognition, while on the other hand, reading is slowed down by the unfamiliarity of word-spaced reading materials. Participants in this study were experienced readers of English and were therefore used to reading word-spaced texts. Previous research found that English native readers are disrupted by interword spacing when reading simple Chinese materials (Everson, 1986; Yao, 2011). It is therefore possible that a negative effect in the Chinese native readers in this study is due to their high level of exposure to English.

With pinyin materials, interword spacing did not appear to facilitate reading. This is in line with previous findings (Author, 2009; King, 1983). Still, pinyin sentences should be read faster with interword spacing, for a variety of reasons. First, interword spacing reduces the number of homophones. Second, pinyin is normally written with interword spacing and therefore removing it should have negative effects. Third, participants experienced more difficulty reading pinyin than reading hanzi, therefore additional clues should have helped them; instead, the lack of correlation between pinyin reading rate and interword spacing effect indicates that interword spacing does not facilitate inexperienced readers. Fourth, participants were experienced readers of

English, a writing system that separates words with spacing, and interword spacing had been added where it would have been in an English translation of the Chinese sentences, which should have facilitated the reading of these Chinese-English biliterates. The lack of a positive effect, together with the high level of individual variation in the effect of interword spacing in pinyin reading, remains to be explained. This might turn out to be due to characteristics of the Chinese language, where words are usually one or two syllables long. When Japanese is written without morphemic information (in kana without kanji), readers are facilitated by the addition of interword spacing (Sainio et al., 2007) presumably because spacing breaks down long strings of syllabic symbols that are normally segmented by the alternation of kana and kanji. With words of one or two syllables, Chinese readers are unlikely to be facilitated by interword spacing the way Japanese readers are.

With regard to the effect of sentence-picture concordance (i.e., whether YES or NO responses were involved), responses with interword spacing were always slower than with inter-morpheme spacing, except for pinyin sentences with a non-matching picture. Since there was no main effect of sentence-picture concordance, the interaction observed in the results indicates that the sentence-picture concordance effect is not due to the fact that the decision processes are slower when inconsistent information is provided, but is better explained as a consequence of facilitation or disruption of linguistic processing of the sentence. It is possible that interword spacing slows down Chinese readers both when reading hanzi and when reading pinyin, but when morphemic information is not provided, and the sentence is primed by an inconsistent picture, then the disrupting effects of interword spacing disappear because spacing provides additional information that helps Chinese readers deal with a particularly difficult reading task.

Experiment 1 found that removing morphemic information slows down reading, as reading rates for pinyin (which represents phonemic information but not morphemic) were much slower than for hanzi (which represent morphemic information but not phonemic). Still, the faster reading rate for hanzi is confounded by participants' lack of practice in pinyin reading. Experiment 2 therefore involved a replication of Experiment 1 but with primary school children, who are widely exposed to pinyin.

Experiment 2: Effects of type of information and spacing on reading in Chinese inexperienced readers

Experiment 1 revealed that Chinese experienced readers are negatively affected in terms of reading rate when only phonemic information is provided, and morphemic information is not provided. This could be due to a variety of reasons. Previous researchers have proposed lack of experience in reading pinyin, or the high number of homophones in pinyin. The second experiment then aims at establishing whether hanzi are read faster because of Chinese adults' lack of practice in reading pinyin, by replicating the first experiment with primary school children as participants. Chinese primary school children are not experienced hanzi readers, and they have much exposure to pinyin. According to Wu et al. (2002), children read only pinyin in their first year, read a mixture of hanzi and pinyin in the second year, and start reading hanzi-only materials in the third year. Therefore, if children read hanzi faster than pinyin this cannot be explained as a consequence of experience in reading hanzi and lack of practice in reading pinyin. If, in spite of practice in pinyin reading and lack of

experience in hanzi reading, Chinese children read hanzi faster than pinyin, the possible explanations are: 1) pinyin does not provide morphemic information directly, as hanzi do, or 2) the high number of homophones in pinyin negatively affects reading. Interword spacing eliminates the issue of homophones, because homophonic orthographic words are much rarer than homophonic monosyllabic morphemes. Therefore, the best explanation for the worse reading of pinyin would be the absence of morphemic information.

Method

Participants were 22 Chinese primary school children, recruited and tested in a school in Nanjing. There were 15 males and 7 females, with a mean age of 8;7. A wide age range (from 7;2 to 10;3) was selected to make results generalisable.

Design, task, materials, apparatus and procedure were the same as those used in Experiment 1 except that the children, unlike the adults in Experiment 1, were not asked questions about the relative difficulty of reading under the different conditions.

Results

Response times for incorrect responses, and for responses during which children had stopped to ask questions or had been distracted, were eliminated from the dataset. Following this, response times of more than 3 standard deviations above the mean for each participant were also eliminated. Preliminary analyses revealed no significant effect of gender on reading rate (hanzi: $t(20) = -1.73$, $p = .099$; pinyin: $t(120) = 1.78$, $p = .091$) or accuracy (hanzi: $t(20) = 1.72$, $p = .101$, pinyin: $t(20) = 0.23$, $p = .821$). The results for girls and boys were therefore combined in the main analysis. The correlation of reading speed and accuracy was not significant, indicating lack of speed-accuracy trade-off. Age did not correlate with reading speed for either hanzi or pinyin sentences ($r = 0.30$, $p = .709$ and $r = -0.11$, $p = .640$).

Table 2 shows mean reading rate and accuracy of responses by type of linguistic information and type of spacing.

Table 2. Mean reading rate (syllables per second) and percentage of correct responses by type of linguistic information and type of spacing for primary school children in Experiment 2 (standard deviations are in brackets)

Linguistic Information	Reading Rate (syllables/sec)		Correct Responses (percent)	
	Morpheme	Word	Morpheme	Word
Morphemic	2.85 (1.21)	2.64 (1.06)	95.67 (4.63)	90.91 (8.04)

|				
(hanzi)				
Phonemic	0.96 (0.26)	0.83 (0.19)	94.47 (6.21)	91.42 (7.39)
(pinyin)				

Separate 2 x 2 repeated-measures ANOVAs were conducted on the reading rate and accuracy data to analyze the effects of linguistic information (morphemic; phonemic) and type of spacing (interword; inter-morpheme).

The ANOVA for reading rate revealed a significant main effect of linguistic information with a large effect size ($F(1, 21) = 65.74$, $p < .001$, partial $\eta^2 = .76$): reading rate was faster for hanzi than pinyin sentences. The effect of type of spacing was also significant ($F(1, 21) = 11.80$, $p = .002$, partial $\eta^2 = .36$): children were faster with inter-morpheme spacing than with interword spacing. The interaction was not significant ($F(1, 21) = .84$, $p = .371$, partial $\eta^2 = .04$). The ANOVA for accuracy revealed that the effect of type of linguistic information was not significant ($F < 1$). There was a main effect of interword spacing with a medium effect size ($F(1, 21) = 11.96$, $p = .002$, partial $\eta^2 = .36$): children were more accurate with sentences with inter-morpheme spacing than sentences with interword spacing. The interaction was not significant ($F < 1$).

Further analyses were carried out to test whether interword spacing has different effects on children's reading rate for sentences that do or do not match the picture. The results are plotted in Figure 2 for pinyin and hanzi sentences.

Figure 2: Mean reading rates (syllables per second) of pinyin and hanzi sentences by sentence-picture concordance (YES response; NO response) and type of spacing (interword; inter-morpheme) for primary school students in Experiment 2
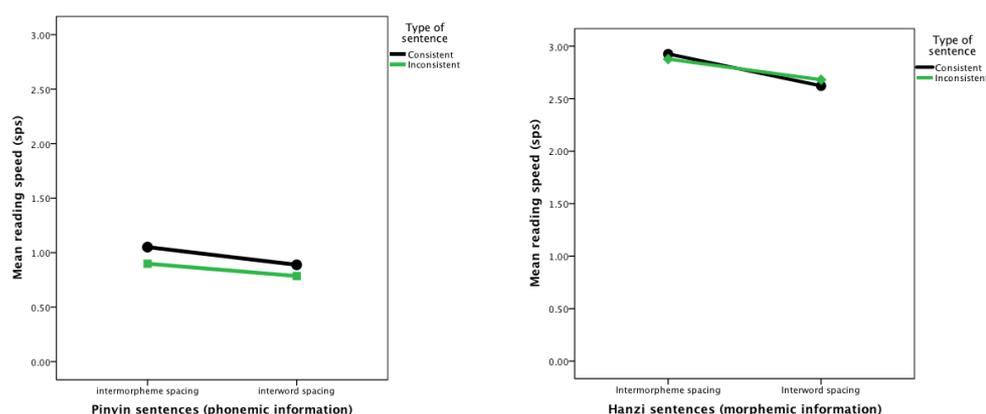
For hanzi sentences the main effect of sentence-picture concordance was not significant ($F < 1$). The main effect of type of spacing was significant, however ($F(1, 21) = 7.39$, $p = .013$, partial $\eta^2 = .27$): the children's reading rate for hanzi sentences was slower with interword spacing than with inter-morpheme spacing. The interaction was not significant ($F < 1$).

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For pinyin sentences the main effect of sentence-picture concordance was significant ($F(1, 21) = 22.92$, $p < .001$, partial $\eta^2 = .52$): sentences that matched the picture were read faster than those that did not match the picture. The main effect of type of spacing was also significant ($F(1, 21) = 16.85$, $p = .001$, partial $\eta^2 = .45$): as for hanzi sentences, reading rate was slower with interword spacing than with inter-morpheme spacing. The interaction was not significant ($F(1, 21) = 1.34$, $p = .261$, partial $\eta^2 = .06$).

Finally, order of presentation (pinyin first or hanzi first) affected the interword spacing effect for hanzi sentences only. Descriptively, interword spacing slowed down reading in the second more than in the first block of trials, across groups. With hanzi materials, interword spacing slowed down the group that read hanzi after pinyin materials by 0.45 syllables per second ($SD = 0.34$), whereas the group that read hanzi first was not slowed down ($M = 0.03$ sps, $SD = 0.37$). With pinyin materials, interword spacing slowed down those who saw pinyin after hanzi more than those who saw pinyin first ($M = 0.15$ syllables per second, $SD = 0.16$ and $M = 0.10$, $SD = 0.14$ respectively). A 2 x 2 mixed ANOVA with order of presentation (pinyin first; hanzi first) as a between-group variable and type of linguistic information (pinyin, hanzi) as a within-group variable was conducted to explore the interword spacing effect on reading rate. There was no effect of type of linguistic information ($F(1, 20) = 1.30$, $p = .268$, partial $\eta^2 = .06$): the interword spacing effect was equally strong with hanzi and pinyin materials. The main effect of order of presentation was significant ($F(1, 22) = 5.69$, $p = .027$, partial $\eta^2 = .22$). The interaction was significant ($F(1, 20) = 12.72$, $p = .002$, partial $\eta^2 = .39$): interword spacing slowed down hanzi reading more in those who saw hanzi after pinyin sentences than in those who saw hanzi before pinyin ($t(20) = 3.17$, $p = .005$, $r = .33$).

Discussion

Effects of type of linguistic information on inexperienced Chinese readers

The results from Experiment 2 indicate that replacing morphemic information with phonemic information has strong negative effects on Chinese inexperienced readers, and that interword spacing negatively affects reading rate as well as accuracy of responses in the sentence-picture matching task. Chinese primary school students read as much as three times more slowly with pinyin than with hanzi sentences, confirming previous findings by Sun (1993) of a 4-times slower sentence reading rate (the lower level of disruption in the present study could be due to the fact that the reading task additionally involved making decisions). The child participants in Experiment 2 were inexperienced readers: compared with the university students in Experiment 1, they read at about half the speed and with about half the number of correct responses, under all conditions. Still, the ratio of about 3:1 in terms of reading rate for hanzi versus pinyin was the same for both the children and the adults, despite the large overall group difference in reading rate for hanzi and pinyin. The children had recently had extensive exposure to pinyin, as is customary in reading instruction for children of the age tested in the present study, and were still not proficient hanzi readers. Future research may investigate in more depth the relationship between age and reading rates in pinyin and hanzi because, in spite of the lack of correlation between age and reading rates in this study, it is to be expected that with age pinyin reading rates decrease and hanzi reading rates increase. At any rate, children's slower reading rate with pinyin compared to hanzi

in this study cannot be explained as a consequence of relative lack of exposure to pinyin, as may be argued to be the case for adults.

Interestingly, compared with English-native-reading learners of Chinese as a Second Language with 3 years' experience of language learning (Author, 2009), Chinese children read hanzi sentences at about the same speed, but read pinyin sentences at about half the speed. L1-English readers of L2-Chinese seem to read pinyin and hanzi at the same speed, at least with simple sentences accompanied by pictures (Author, 2009). This is likely to be partly due to recent experience with pinyin, and to experience with the roman alphabet in general, but, more likely, is due to the cross-orthographic effects of a first language writing system which mostly represents phonology. Previous research found that L1-English readers of L2-Japanese read faster than Japanese native readers when only phonological information is provided, that is, reading Japanese texts written only in kana (syllabic graphemes) without kanji (Everson, 1993). It is likely that L1-English readers of L2 Chinese need morphemic information less than Chinese native readers, at least with simple sentences. These readers are therefore not disrupted when phonological rather than morphemic information is provided, because they are used to a first language writing system that requires phonological recoding prior to lexical access.

Finally, it was noticed that some children were subvocalising while reading romanised sentences, but nobody subvocalised when reading hanzi. If inexperienced readers recoded hanzi into phonology in order to comprehend sentences, then they should sound out hanzi as well as pinyin. Since subvocalisation was only noted with pinyin materials, this seems to confirm that pinyin reading requires phonological recoding for lexical access, whereas hanzi reading does not.

Effects of type of spacing on inexperienced Chinese readers

The results from Experiment 2 revealed that Chinese inexperienced readers were slower to read sentences with interword spacing than inter-morpheme spacing, both for hanzi and for pinyin. This was the case both when sentences were accompanied by a matching picture or a non-matching picture, and negative effects were also apparent, albeit not as strongly, in accuracy of responses. These negative effects are in line with the results from adult participants in Experiment 1, who were disrupted by interword spacing when reading hanzi. However, the findings from Experiment 2 are not in line with previous research that found no effects of interword spacing on Chinese children's reading (Shen et al., 2010).

These negative effects on reading rate and comprehension should therefore be further investigated. The lack of correlation between the interword spacing effect and reading rate could show that interword spacing does not facilitate poorer readers, in line with findings by Shen et al. (2010) who compared the effects of interword spacing in good and poor year-3 primary school readers and found no differences. This possibility could be tested on children of different ages, bearing in mind the wide age range of children in the present study. The lack of positive effects of interword spacing might be because interword spacing is unfamiliar to Chinese children: pinyin is conventionally written in orthographic word units, but when it is used to gloss hanzi it is written in syllabic units. Still, adult participants were very familiar with interword spacing because of their English proficiency, and were still not facilitated by it. Furthermore, lack of familiarity would be expected to result in a lack of effect; the negative effects show that interword spacing had an interfering effect.

Far from being facilitated by interword spacing, Chinese inexperienced readers were more disrupted than experienced readers. This pattern differs from that shown by another group of inexperienced readers of Chinese, namely L1-English readers of L2-Chinese. While interword spacing has no effects on English readers of hanzi sentences, it facilitates their reading of pinyin sentences (Author, 2009) and of more complex hanzi texts (Author & Lu, 2011). The positive effects of interword spacing on L2 readers is therefore not due to their lack of reading proficiency, but it is most likely a cross-orthographic effect due to the importance of interword spacing in their L1 writing system. Furthermore, the positive effect disappears with higher levels of reading proficiency, and interword spacing can then even be disruptive (Everson, 1986; Yao, 2011).

General Discussion

Effects of type of linguistic information on experienced and inexperienced Chinese readers

Taken together, the results from the two experiments shed light on the possible causes of the slower reading of pinyin compared with hanzi, and indicate that most likely pinyin is read more slowly because it does not provide morphemic information. Explanations for differences in pinyin and hanzi reading rate put forward in the past have included lack of experience in reading pinyin (Fu et al., 2002; Sun, 1993). Since Chinese primary school students are unproficient hanzi readers and are much exposed to pinyin, the fact that child participants in this study read hanzi faster than pinyin indicates that the effect of type of linguistic information is not due to lower levels of pinyin reading proficiency, or at least not solely due to this reason. Another explanation that has been proposed is the high number of homophones in pinyin (Sun, 1993). Since participants in this study read pinyin more slowly than hanzi even with interword spacing, it appears that the slow reading of pinyin is not due to the high incidence of homophones, because pinyin texts are full of homophones when pinyin is written in syllabic units, but when pinyin is written in orthographic word units there are few homophonic words.

Other researchers argued that pinyin is read more slowly because it is read by means of assembled phonology, while the addressed phonology used for hanzi is faster (Fu et al., 2002). While the present study did not examine this explanation, it seems unlikely. Pinyin has a total of 400 written syllables (or 1,300 including tones), composed out of a total of 21 onsets and 35 rimes. Given the small number of written onsets and rimes and the relatively small number of written syllables, children are taught to read pinyin using a whole-syllable approach, or using onset and rime, rather than letter-by-letter, and onset-rime awareness rather than phonemic awareness is a predictor of reading in Chinese children (Siok & Fletcher, 2001). Although pinyin represents phonemic information, there is no evidence that it is processed at the phonemic level rather than at the onset-and-rime or syllable level. Furthermore, pinyin syllables contain between one and three graphemes (e.g., *a*, *zheng*). It is then not clear why assembling one to three graphemes (or two strings of letters if pinyin is read by recognising onset and rime) should be slower than recognising a hanzi, considering the level of visual complexity of hanzi. Furthermore, many researchers would argue that hanzi are not read as units, and that hanzi recognition, at least for some hanzi, involves

assembling the semantic and phonetic radical. Therefore it seems unlikely that pinyin is read more slowly because of the different speeds of assembled and addressed phonology. Familiarity with pinyin most likely plays a role. Still, considering that pinyin is read more slowly than hanzi by children as well as adults, both when it is written in orthographic word units and when in syllable units, the most likely reason why hanzi are read faster is because pinyin does not provide morphemic information.

Effects of type of spacing on experienced and inexperienced Chinese readers

Regarding the effects of spacing, the findings from the two experiments on adults and children reported above indicate that interword spacing does not facilitate Chinese readers, and can have negative effects on reading speed and comprehension. The effect appears to be more evident when participants have been primed to notice the presence of interword spacing by being exposed to a set of materials with interword spacing, especially if the materials are written in romanised Chinese where interword spacing is more visible and normally used and therefore more salient. In particular, interword spacing did not facilitate inexperienced Chinese readers, and on the contrary it was shown to have more negative effects than for experienced readers. While interword spacing facilitates inexperienced readers of Chinese as a second language, this is likely to be an effect of a word-spaced first language writing system, rather than an effect of lack of proficiency.

An interesting finding that sheds light on the nature of the interword spacing effects on Chinese readers comes from the comparison in the present study of adults' reading rate for sentences that matched the picture and those that did not. The adults were always disrupted by interword spacing, except when reading romanised Chinese sentences that were presented with a non-matching picture. It appears that the negative effect of interword spacing disappeared in this case because spacing can help Chinese readers when they are dealing with unusual circumstances, such as context-less ambiguous sentences (Hsu & Huang, 2000a) or moving texts in single-line displays (Shieh et al., 2005). Interword spacing does not provide blanket help to poor or inexperienced readers: it does not help adults deal with pinyin reading, and it does not help children whether reading hanzi or pinyin. It only helps when readers are confronted with an unusual reading task.

Implications

The results of this study can contribute to debates about whether, and how much, our current views of reading processes are English-centric. A few years ago the writing systems expert Florian Coulmas wrote: "it is safe to say that most research on reading has been informed by explicit and implicit assumptions about alphabetic writing systems and their scientific descriptions" (Coulmas, 2003, p. 212). Although the situation is constantly improving and much cross-orthographic research is shedding light on differences among writing systems and their reading and writing processes, it is still the case that research on English is often the starting point. Probably for this reason there is research on the presumed facilitative effects of adding interword spacing to Chinese or Thai, but little or no research on the potential facilitative effects of adding morpheme boundary markers in English; and there is much more research on phonological than morphological processes in reading, although most writing systems represent both phonological and morphological information to some extent.

The results of this study can also contribute to debates about proposed reforms of the Chinese writing system. There seems to be currently no debate about replacing

hanzi with pinyin, a possibility that was widely discussed in the 1950s, but there are researchers who believe that replacing hanzi with romanisation would benefit Chinese society. The present results indicate that pinyin is less easy to read than hanzi, even for beginning readers. There have also been proposals to introduce interword spacing in Chinese. The present study indicates that interword spacing does not facilitate inexperienced readers, and it may even disrupt reading rate and comprehension. Therefore in the light of these preliminary and limited findings, neither romanising Chinese nor introducing interword spacing appear to be desirable writing system reforms.

Finally, these results also have pedagogical implications. In Japan, reading materials for children are written with *wakachigaki* (separated writing), whereby spacing separates orthographic phrases rather than orthographic words, whereas materials for learners of Japanese as a Second Language are segmented into orthographic words. Perhaps, for children acquiring literacy in a non-word-spaced writing system, spacing is better used to separate prosodic units or units of meaning, in line with research into chunking in inexperienced readers of English. Given that learning interword spacing conventions is a difficult task for children learning to read alphabetic writing systems (Ferreiro, 1999), and given that both linguists and laypersons have difficulty agreeing on Chinese word boundaries (Author, 2005; Duanmu, 1998), interword spacing might be an additional burden for Chinese children acquiring literacy, and could possibly also be detrimental to experienced readers. The issue of the best segmentation of print for Chinese children deserves to be researched, and it might well turn out to be something other than orthographic word segmentation.

Conclusions

The Chinese writing system represents morphological information by providing different written forms for homophonic morphemes, for instance having different hanzi for 衣 (dress), 医 (doctor) and 一 (one), all pronounced /i1/. This information is crucial to Chinese reading processes, and when it is removed reading is negatively affected. Phonological recoding alone does not allow for efficient reading in either experienced or inexperienced Chinese readers. Chinese readers who see 衣 or 医 are then not simply recoding these hanzi as /i1/, they are also recognising these morphemes, as probably do English readers when they read <flour> and <flower>. This does not mean that Chinese reading involves no phonological recoding, it means that hanzi reading involves recoding morphemic units as well as phonological (syllabic) units.

Written languages also use orthographic marks to visually organise the written representation of language. In English and in most alphabetic writing systems, spacing separates orthographic words and it facilitates reading. This does not mean that interword spacing universally facilitates reading. The present study shows that interword spacing does not facilitate the reading of either experienced or inexperienced Chinese readers.

Acknowledgements:

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