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The Early Extraction of Sublexical Phonology in Reading Chinese Pseudocharacters: An Event-related Potentials Study*

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This event-related potentials (ERPs) study attempts to trace the time course it takes to extract phonology while reading Chinese pseudocharacters. Participants were asked to passively attend to a set of pseudocharacters, each paired with a spoken syllable. This syllable had either a predicable or an unpredictable pronunciation, which was determined by the constituent phonetic radical of the pseudocharacter. The data showed that pseudocharacters paired with predictable or unpredictable pronunciations elicited different ERPs and suggested that Chinese pseudocharacters are pronounceable. Furthermore, pseudocharacters paired with unpredictable pronunciations elicited two greater frontal positivities, p2a and p2b, and an enhanced N400. P2 component could be used to index the early extraction of phonology in reading Chinese pseudocharacter; N400 was associated with the post-lexical processing. These findings suggest that phonetic radicals could be used to suggest pronunciation in the early stage of Chinese lexical processing.

Key words: ERPs, pseudocharacter, event-related potential

1. Introduction

Various models of word recognition can be used to make different predictions for reading pseudowords. The connectionist model proposes that there is a single mechanism for converting printed words or pseudowords into speech sounds and that the naming of pseudowords should be affected by the existence of orthographic and phonological knowledge of words (Glushko 1979, Seidenberg & McClelland 1989, Seidenberg et al. 1994). For instance, -*ean* in word-final position is always pronounced as /in/ in English,

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whereas -*eat* in the same position has various pronunciations in different words (e.g., *treat* vs. *threat*). One study has demonstrated that pseudowords derived from words with inconsistent endings (e.g., *breat*) take longer to be named than do pseudowords derived from words with consistent endings (e.g., *hean*). The effect of consistency in naming pseudowords is regarded as evidence supporting single-route models (Glushko 1979). The traditional dual-route model, however, assumes that all pseudowords can only be pronounced by a nonlexical route operated by grapheme-to-phoneme corresponding rules (GPC rules) and thus predicts that there is no such difference between these two types of pseudowords (Coltheart 1978, 1983). The current computational version of dual-route model can incorporate the consistency effect in pseudowords by assuming both lexical and nonlexical routes share the initial stage of letter identification and the final stage of phonemic representation (Coltheart et al. 1993, Coltheart et al. 2001). Reading pseudowords will activate a set of visually similar words and these, in turn, will activate the corresponding phonological representations. Therefore, in the phonological buffer, if the phonological representations activated by the lexical system and those derived from the nonlexical procedure conflict with each other, a delay will occur in naming. The single and dual-route models also make different predictions on how words and pseudowords might be read in context created by lists composed of different stimuli or task requirements. Studies to investigate the reading performance of pseudowords play an important role in distinguishing different models of word recognition, and attempt to shed light on the sublexical processing.

Chinese is characterized as an ideographic writing system. Unlike alphabetic script in which words are comprised of letters which represent phonemes, Chinese characters are thought to be composed of radicals that cannot be assembled or combined to produce a larger phonological unit that would represent the character's sound. The correspondence between orthography and phonology in Chinese is considered more arbitrary or opaque than in writing systems with shallow orthographies, such as Serbo-Croatian, Italian, or English. Furthermore, more than 85% of all Chinese characters are phonograms; the composed phonetic radicals might be used to specify the pronunciation of the whole character. In fact, only 39% of these characters have the same pronunciation as their phonetic radicals, leading some researchers to believe that the sublexical generation of phonological representations is impossible for Chinese (Paap & Noel 1991, Valdes-Sosa et al. 1993, Liu et al. 1996). However, several studies have probed the issue of sublexical phonological processing in naming Chinese using either indices of regularity or indices of consistency to describe the mappings between Chinese orthography and phonology (Lien 1985, Seidenberg 1985, Fang et al. 1986, Hue 1992). Regularity refers to whether the sound of a character is identical with that of its phonetic radical or not. Behaviorally, the naming speed for irregular characters is much slower than regular characters, especially for low frequency characters. This is the so-called frequency-by-regularity interaction, which suggests Chinese phonograms are not read via a direct association between orthography and phonology, but through the process of sublexical phonology (Lien 1985, Seidenberg 1985, Fang et al. 1986, Hue 1992). However, many phonetic radicals of phonograms are not legitimate characters and are thus unpronounceable. The concept of regularity thus cannot be applied to this kind of phonogram, since the definition of regularity is based on whether the phonograms and their phonetic radicals sound the same. Alternatively, the phonological relationship between phonogram and phonetic radical can be addressed by consistency. Consistency refers to whether a character's pronunciation agrees with those of its orthographic neighbors, which, by definition, contain the same phonetic radical. Many studies have demonstrated the frequency by consistency interaction in naming Chinese phonograms and suggest the phonological information provided by the sublexical unit plays a role in reading Chinese phonograms (Hue 1992, Lee et al. 2004, Lee et al. 2005).

The other way to address whether the phonological information is encoded in the phonetic radical is to examine how people read pseudocharacters. Chinese pseudocharacters can be created by arbitrarily combining a semantic radical with a phonetic radical. Some researchers believe that Chinese characters must be learned by rote memorization and that only entries in a dictionary have pronunciation in Chinese. In other words, Chinese pseudocharacters have no pronunciation (Liu et al. 1996). However, previous studies have demonstrated that Chinese pseudocharacters are pronounceable (Lien 1985, Tzeng et al. 1995). Furthermore, these studies constructed a set of pseudocharacters which varied from one another in the degree of consistency in the phonetic radicals and gave them to skilled and beginning readers to name. If the readers simply adopted the read-the-phonetic radical strategy to deal with a pseudocharacter, there was no difference in naming latencies or types of error for reading pseudocharacters with different consistency values. However, the pattern of pseudocharacter naming highly resembled the consistency effect of real character naming in that high consistency pseudocharacters were read faster than low consistency pseudocharacters (Lien 1985, Tzeng et al. 1995). These findings indicate that Chinese readers also use the knowledge of orthography-phonology correspondences in naming Chinese characters and pseudocharacters.

An unsolved problem is the locus of the sublexical phonology in reading Chinese. Liu and his colleagues (1996) claimed that there was no pre-lexical phonology involved in reading Chinese. They gave two reasons. First, the frequency-by-regularity interaction was usually present in naming or in tasks involving phonological analysis but absent in lexical decision tasks. Second, naming task in Chinese mainly involves post-lexical processing (Liu et al. 1996). However, one current study measuring duration of eye fixation while reading naturally (without phonological demand) found significant evidence of consistency effect in phonological preview benefits. This finding suggests that phonological computation is rapid and early at both character and radical levels when identifying Chinese characters (Tsai et al. 2004). It seems that whether the locus of consistency effect in reading Chinese characters takes place at an early or late stage of lexical processing is still not known.

To answer this question, this study uses event-related potentials (ERPs) to examine the time course of sublexical orthography-to-phonology transformation in reading Chinese pseudocharacters. ERP methodology can be advantageous in language research. First, the measurement of reaction time reflects the summation of all the steps that elapse prior to the language task's behavioral response. Contrarily, ERP methodology can provide insight into the time course of language comprehension because it can provide data that reflect processing at each millisecond from the onset of the language stimuli. Another appealing characteristic of ERP is that task demands do not need to be imposed on the participants unless they are experimentally interesting. Simple reading or listening is sufficient to elicit different ERP as a consequence of some psycholinguistic manipulation. Previous electrophysiological literature has described several ERP components associated with early and later stages of lexical processing (Bentin 1989, Barnea & Breznitz 1998, Sereno et al. 1998, Liu et al. 2003, Misra & Holcomb 2003, Proverbio et al. 2004). For example, P100 is thought to be related to word form analysis (Nobre et al. 1994); P200 occurs when reading an irregular word and comparing it with a regular word, and it has been associated with the extraction of the orthographic and phonological features of words occurring at the stimuli-classification stage early in information processing (Barnea & Breznitz 1998, Sereno et al. 1998). N400 and late positive component (LPC) have been used to index the late processing in semantic integration and lexical competition (Curran et al. 1993, Bentin et al. 1999, Misra & Holcomb 2003).

In the present study, participants see a set of pseudocharacters which were created by compounding a semantic radical and a phonetic radical. The phonetic radical had to be decomposed from a consistent character. Each pseudocharacter was paired with a pronunciation, deemed either predictable or unpredictable based on its phonetic radical. Naming pseudocharacters has been considered an unnatural task for Chinese readers and whether the pseudocharacters are pronounceable is still in debate. The advantage of this study is that the participants were not asked to name pseudocharacters but only to passively listen to the paired spoken syllables. These syllables had either predictable or unpredictable pronunciations determined by the constituent phonetic radicals of the pseudocharacters. If pseudocharacters were unpronounceable, or the pseudocharacters did not automatically activate their pronunciations, the paired predictable or unpredictable pronunciations should make no difference. Contrarily, if pseudocharacters were pronounceable and their pronunciations were generated from the sublexical phonology, paired with predictable or unpredictable pronunciation, they should elicit different ERPs. Furthermore, whether predictability effect was manifested at early or late ERP components will be used to examine the locus of sublexical computation of phonology.

2. Method

2.1 Participants

Twenty-four college students (12 women and 12 men) were paid US$20 per experiment for their participation. Ages ranged from 19 to 26 years (mean age = 22.6 yrs.). Data from 4 participants (3 women and 1 man) were excluded from analysis due to excessive movement artifacts (more than 70% of epochs were rejected). All participants were native Chinese speakers with no history of neurological or psychiatric disorders. They either had normal or corrected-to-normal vision. Written consent was obtained from all participants. Research protocol was approved by the institutional review board of Academia Sinica.

2.2 Material and design

One hundred and eighty Chinese pseudocharacters were created. Each pseudocharacter was configured horizontally with a semantic radical on the left and a phonetic radical on the right. All the phonetic radicals used to create the pseudocharacters were decomposed from consistent characters. Consistent characters were defined as a set of phonograms that share the same phonetic radical and have the same pronunciation. Half of the pseudocharacters were assigned to a group that had predictable pronunciations and the other half were assigned to a group with unpredictable pronunciations. Pronunciation of a pseudocharacter was defined as predictable if this pronunciation was the same as those in a whole set of real phonograms containing the same phonetic radical. Otherwise, it was unpredictable (see illustrations in Figure 1).

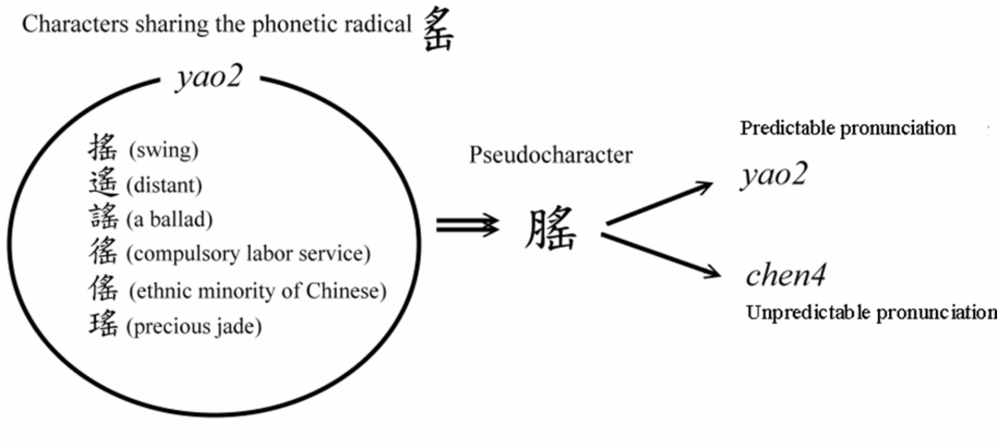

Figure 1: Examples of pseudocharacters paired with predictable or unpredictable pronunciation. A character is defined as consistent if its pronunciation agrees with those of its orthographic neighbors (all characters containing the same phonetic radical). The pseudocharacter was created by changing the semantic radical. The peudocharacter's pronunciation was defined as predictable if it was the same as those in a whole set of real phonograms containing the same phonetic radical. Otherwise, it is unpredictable.

We compared brain waves elicited by the pseudocharacters paired with predicted and with unpredicted pronunciations. To ensure all participants paid attention to all the pseudocharacters and the paired pronunciations, each pseudocharacter was followed by a real character for homophone judgment. The pronunciation of the following real character either sounded the same or different from the previous assigned pronunciation for the paired pseudocharacter. The sound waves were downloaded from the Taiwan Native Language Translation and Text-to-Speech Synthesizers of National Taiwan University Natural Language Processing Lab (http://nlg.csie.ntu.edu.tw/systems/TWLLMT/). Averaged length of sound wave was 270ms. Neither the paired pseudocharacter nor the following character for homophone judgment shared the same phonetic or semantic radical.

2.3 Procedure

Participants were seated in front of a monitor at a distance of approximately 60 cm in a dim room. During the experiment, each participant was presented with 180 pseudo-characters in random order. For each trial, a fixation appeared at the center of the screen for 500ms. It was replaced by a pseudocharacter for 500ms. The pseudocharacter was paired at the onset with either a predictable or unpredictable pronunciation. After 1000ms, a real character was presented at the center of screen and the participant was asked to make a homophone judgment, in which he or she was to decide whether the character sounded the same as the paired pronunciation for the previous pseudo-character. All participants were instructed to respond by pressing the button of the mouse as quickly and as accurately as possible. The index finger indicated "yes" and the middle finger "no." The probe character remained on the screen until the participant responded or until an interval of 2000ms had expired. Performance on homophone judgment was used to evaluate whether the participant had paid attention to the paired sound for the pseudocharacters. After the disappearance of the probe, a bold capital letter "B" was then presented for 2000ms to signal participants to make a quick blink before next trial if necessary. The fixation of next trial began 500ms after the blinking signal "B" disappeared. A diagram of a trial is shown in Figure 2. Participants were given 20 practice trials. If a minimum of 85% accuracy was not reached, the practice was repeated. The 180 trials done in this experiment were divided into three blocks. Each block lasted around seven minutes. A five-minute break was given between blocks.

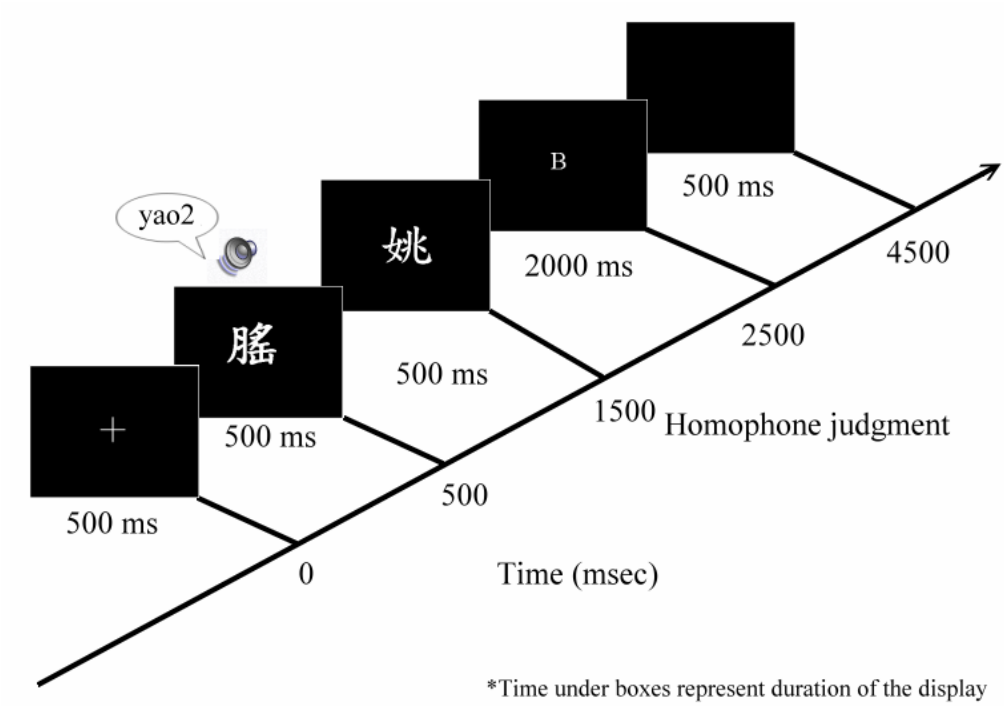

Figure 2: The diagram of an experimental trial

2.4 ERP recording and analysis

The electroencephalogram (EEG) was recorded from 64 sintered Ag/AgCl electrodes (QuickCap, Neuromedical Supplies, Sterling, USA). The electrode locations (American Electroencephalographic Society 1991) consisted of Fp1, Fpz, Fp2, AF3, AF4, F7, F5, F3, F1, Fz, F2, F4, F6, F8, FT7, FC5, FC3, FC1, FCz, FC2, FC4, FC6, FT8, T7, C5, C3, C1, Cz, C2, C4, C6, T8, TP7, CP5, CP3, CP1, CPz, CP2, CP4, TP8, P7, P5, P3, P1, Pz, P2, P4, P6, P8, PO7, PO5, PO3, POz, PO4, PO6, PO8, CB1, O1, Oz, O2, CB2. EEG data were recorded with a reference located between Cz and CPz. An average mastoid reference was derived off-line using both left and right mastoid data. Vertical eye movements were recorded by electrodes placed on the supra- and infraorbital ridges of the left eye, and horizontal eye movements by electrodes placed lateral to the outer canthi of the right and left eyes. A ground electrode was placed on the forehead anterior to Fz. Electrode impedances were kept below 5 KΩ. EEG was continuously recorded, digitized at a rate of 500Hz. Signal was amplified by SYNAMPS2® (Neuroscan, Inc.) amplifiers with the band-pass at 0.05-100Hz for off-line analysis.

All EEG data were first epoched by 100ms prior to the onset of pseudocharacter and 924ms after onset of the pseudocharacter. The 100ms pre-stimulus was used for baseline correction. Artifact rejection was performed in two stages. The first stage was eye-movement rejection in which trials with voltage variations larger than 100μV in either VEOG or HEOG were rejected. In the second stage trials with voltage variations larger than 50μV in at least one of the remaining channels were rejected. The data were then band-pass filtered between 0.5~30 Hz (zero phase shift mode, 12 dB/oct). ERPs for pseudocharacters paired with predictable and unpredictable pronunciations were computed for every subject at every electrode site by averaging over corresponding trials.

3. Results

3.1 Behavioral data

Mean reaction times (RTs) and error rate for homophone judgment are summarized in Table 1. Analysis was carried out using repeated measures ANOVA with factors of predictability and response type. Analysis of RT data revealed significant main effect for predictability ($F(1,19)=5.72$, $MSe=290.69$, $p<.05$) and the interaction between predictability and response types ($F(1,19)=9.27$, $MSe=508.09$, $p<.05$). No significant main effect revealed for response types ($F(1,19)=1.28$, $p>.2$). Post-hoc comparisons showed significant simple main effect of response type in the unpredictable condition ($F(1,38)=6.27$, $MSe=1012.98$, $p=0.017$), but not in the predictable condition ($F(1,38)= 0.30$, $MSe=1012.98$, $p>0.5$).

Table 1: Means of Correct Reaction Times (in milliseconds) and Mean Percentage Error Rates (ER) as a Function of Predictability and Response Types for CI2.

	Predictability							
	Predictable				Unpredictable			
	RT		ER		RT		ER	
Response types	M	SD	M	SD	M	SD	M	SD
Match	611.97	91.07	0.07	0.04	605.74	75.63	0.079	0.03
Mismatch	606.47	79.23	0.009	0.015	630.93	76.58	0.012	0.019

Analysis of the error rate found the only significant main effect of response types $F(1,19)=138.74$, $MSe=0.001$, $p<.001$. Neither the main effect of predictability ($F(1,19)= 0.64$, $p>.4$) nor the interaction between predictability and response types ($F(1,19)=0.06$, $p>.6$) reached statistical significance.

3.2 ERP data

Grand average ERPs elicited by the pseudocharacters paired with predictable and unpredictable pronunciations in nine electrodes are shown in Figure 3. After the presentation of pseudocharacter, small exogenous potentials (P1, N1) were seen and did not seem different for predictable or unpredictable conditions. After P1 and N1 were seen, early frontal positivity/occipital negativity was seen (P2a/N2) peaking between 150-200ms and another late frontal positivity (P2a) was seen peaking between 200ms and 300ms. Both P2a and P2b appeared to be more positive for the unpredictable condition than the predictable condition. Later a negative going wave peaking at around 400ms and developing with frontocentral maximum also appeared much larger for unpredictable than predictable conditions. Visually, we identified the temporal windows for the ERP components of interest to us: P2a (150-200ms), P2b (200-300ms), and N400 (350-550ms). The mean amplitude of each time window from each electrode served as dependent measures in a repeated measures analysis of variance (ANOVA). In order to examine the effect of predictability and their scalp distribution, both within-subject factors of predictability (predictable and unpredictable) and electrode (9 electrodes: F3, C3, P3, Fz, Cz, Pz, F4, C4, P4) were included.[1] In all ANOVAs, the degrees of freedom of F ratios were corrected by the Geisser-Greenhouse procedure for

[1] To ensure that response type (match/mismatch) had no impact on the brain potentials elicited by the presentation of the pseudocharacter, mean amplitudes of each time window of p2a, p2b, and N400 entered a three-way ANOVA (predictability x response types x electrode site). As expected, for these three ERP components, response types did not show main effect or interact with the other factors ($p>.1$). The factor of response types was, thus, dropped from further analysis.

controlling the Type I error associated with inhomogeneity of covariance (Keselman & Rogan 1980).

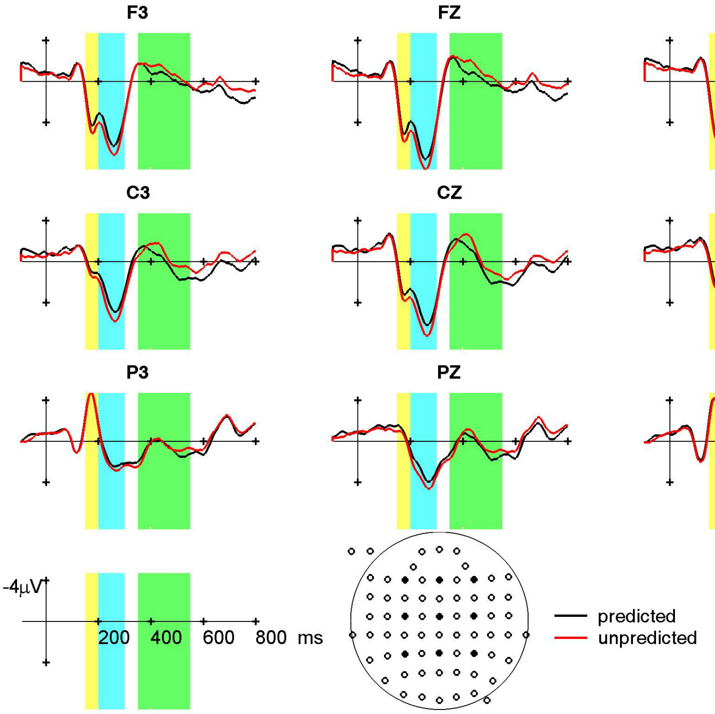

Figure 3: The grand average ERPs elicited by the pseudocharacters paired with predictable pronunciations (black line) and unpredictable pronunciations (red line).

3.2.1 P2a (150ms-200ms)

Both the main effects of predictability ($F(1,19)=16.34$, $MSe=1.011$, $p<.01$) and electrode ($F(1.91,36.38)=47.83$, $MSe=29.644$, $p<.001$) achieved statistical significance. The interaction between predictability and electrode was also significant, $F(3.48,66.11)=3.74$, $MSe=.0303$, $p<.05$. Post-hoc contrasts demonstrated that significant effects of predictability, showing larger P2a in unpredictable conditions than in predictable conditions were found in the electrodes of F3, C3, Fz, Cz, Pz, F4, C4 (p's<.01), but not in electrodes P3 and P4 (p's>.5).

3.2.2 P2b (200ms-300ms)

The main effects of predictability ($F(1,19)=30.05$, $MSe=1.592$, $p<.001$) and electrodes ($F(1.78,33.77)=15.65$, $MSe=30.701$, $p<.001$) and their interaction (F(4.32, 82.06)=6.15, MSe=0.148, p<.001) all reached statistical significance. The post-hoc comparison showed that the unpredictable condition elicited greater positivity of P2b than predictable condition in the electrodes of F3, C3, Fz, Cz, Pz, F4, C4 (p's<.01), though this effect was only marginally significant in electrodes P3 (p=.022) and P4 (p=.015).

3.2.3 N400 (350ms-550ms)

In this time window, the main effects of predictability (F(1,19)=8.62, MSe=2.139, p<.05) and electrodes (F(2.23,42.42)=9.99, MSe=5.535, p<.001) and their interaction (F (3.39,64.35)=5.08, MSe=0.204, p<.05) all reached statistical significance. The post-hoc comparison showed the unpredictable condition elicited greater negativity in this time window than predictable condition in the electrodes of F3, C3, Fz, Cz, F4, C4 (p's<.01), but not for the posterior electrodes of P3, Pz, and P4 (p's>.2).

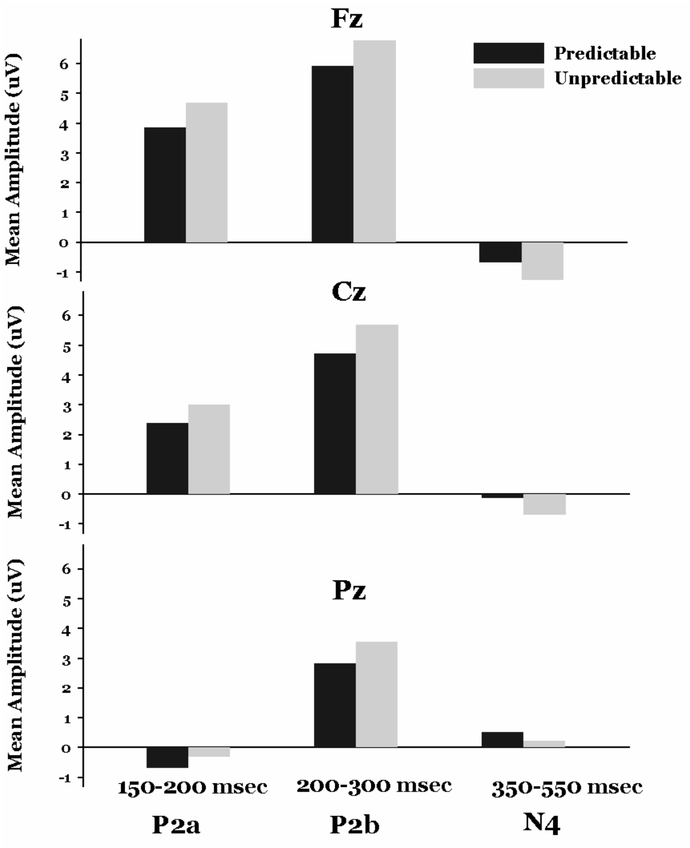

Figure 4

4. Discussion

This ERP study attempts to trace the time course of orthography-to-phonology transformation in reading Chinese pseudocharacters. Participants were asked to passively attend to the pronunciations which were paired with the pseudocharacters without naming demand. The data showed that pseudocharacters paired with predictable and unpredictable sounds elicited different ERPs and suggested that reading pseudocharacters can automatically generate their pronunciations. In the other words, Chinese pseudocharacters are pronounceable, at least those with embedded phonetic radicals that could be used to suggest their pronunciation. This evidence disputes the impression that only entries in a dictionary have pronunciations in Chinese or that the Chinese pseudocharacter has no pronunciation. In addition, the effect of predictability was manifested on three ERP components: P2a, P2b, and N400. These three ERP components have been associated with different cognitive processes, which might be used to suggest the possible mechanism for the extraction of phonology in reading Chinese pseudocharacters.

Pseudocharacters paired with unpredictable sounds elicited two much-enhanced frontal positivities, P2a and P2b, peaking right before and after 200ms (around 170ms and 250ms) respectively than those paired with predicted sounds did. These findings suggest that these two components are involved in the early extraction of phonology for reading Chinese pseudocharacters. Previous studies have reported P2 to be a positive-going waveform evoked at about 200ms and thought to reflect both exogenous (relating to sensory activity) and endogenous (relating to cognitive processing) processing (McDonough et al. 1992, Dunn et al. 1998). The P2 has been used to index mechanisms related to feature detection (Luck & Hillyard 1994), selective attention (Hackley et al. 1990), and other early sensory stages of item encoding (Dunn et al. 1998). Most prior ERP studies have not examined the early components of the brain waveform for lexical processing. A few studies have, however, examined the role of P200 in lexical processing. For example, Byring & Jarvilehto (1985) reported that the prolonged P2 latency was related to more errors in spelling (Byring & Jarvilehto 1985). Sereno and his colleagues (1998) also demonstrated that the difference between low frequency regular and irregular words was evident in P2 at 168 post-stimulus and suggested that it was associated with the spelling-to-sound correspondence. These are congruent with our findings, suggesting that P2 is associated with the extraction of the orthographic and phonological features of words occurring at the stimuli-classification stage early in information processing.

Some other indirect evidence comes from the studies of dyslexics, a population known to have reading and spelling difficulties caused by core phonological deficits. Breznitz & Meyler (2003) found that P2 latencies occurred later among dyslexics (peaking at 210ms) than in normal readers (peaking at 185ms) when responding to sublexical linguistic stimuli (grapheme and phoneme) (Breznitz & Meyler 2003). However, this group difference in P2 latency was absent in non-linguistic tasks. Breznitz & Misra (2003) showed that adult dyslexic readers had significantly more delayed P200 latencies than control readers for the lexical decision task which involved higher level orthographic and phonological processing, but not in the tasks only involving auditory and visual processing for non-linguistic and linguistic stimuli (Breznitz & Misra 2003). One explanation for this difference is that the identification and classification of simple, nonlinguistic stimuli was the least demanding for dyslexic readers, whereas processing linguistic stimuli may have involved additional operations, such as phonological recording of grapheme. This process may have begun early in the cognitive process and indexed by P2 component. The P2a and P2b found in our study had spatio-temporal distributions and eliciting properties similar to those studies, suggesting that they represent the same component possibly related to orthographic and phonological processing.

Our data also shows that pseudocharacters paired with unpredictable sounds elicited larger negativity around 400 to 450ms post-stimulus than those paired with unpredictable sounds. These findings are congruent with studies in the old phonological ERP literature based on indirect tests such as rhyming or vowel/consonant decision tasks (Rugg 1984, Lovrich et al. 1986, Rugg & Barrett 1987). For example, Rugg (1984) found that ERPs elicited by rhyming and non-rhyming words were differentiated by a late negative component (N450) prominent in ERP waveforms elicited by the non-rhyming words and suggested the N450 could be used to index the phonological incongruity. A later study identified the same N450 component in relation to the degree of orthographic and phonological similarity between word pairs and suggested that N450 was sensitive to both orthographic and phonological processing. Valdes-Sosa and his colleagues (1993) measured ERPs in a Chinese phonological matching task by using pairs of logographically dissimilar Chinese characters (Valdes-Sosa et al. 1993). The authors proposed that sublexical assembly of phonology was not used in reading Chinese characters and the members of each pair were logographically dissimilar. Match and mismatch trials did not suffer in the amount of orthographic or sublexical phonological priming. Thus, the enhanced N400 they observed in non-matching pairs could not be associated with orthographic priming, nor with sublexical phonology, but would probably be associated with postlexical processing. Our findings support the proposal that the N450 may not be associated with orthographic priming. However, its relation with the sublexical phonology cannot be ruled out, since the current N400 effect reflected the predictability of the sublexical unit-phonetic radical, in predicting the pseudocharacter's pronunciation.

In summary, the present study demonstrates that two P2 related components, P2a and P2b, and N400 are sensitive to the sublexical phonological extraction in reading

Chinese pseudocharacters. Since P2 had been associated with prelexical processing and N400 was associated with post-lexical processing, our data suggests that P2a and P2b could be is associated with the early extraction of phonology from the orthographic features occurring at the stimuli-classification stage in reading processing. Future studies are needed to differentiate the nature of P2a and P2b in relation to lexical processing.

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以事件誘發電位探討
中文假字閱讀中的早期字音提取歷程

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本事件誘發電位 (event-related potentials: ERPs) 研究旨在利用中文假字唸名探討漢字閱讀中讀音提取的歷程。實驗中，受試者會看到一組意旁在左音旁在右所造出的假字。每個假字呈現的同時，也會出現一個語音。這個語音可能是該假字音旁所預期或無法預期的讀音。實驗結果發現，中文假字配對可預期與不可預期之讀音會引發不同的腦電波反應，證實音旁具有提取讀音的作用。而腦電波的差異主要發生在額葉的兩個連續正波，P2a 與 P2b，以及 N400 的成分上。由於過去的研究指出 P2 的成分主要與文字辨識歷程中早期的特徵提取有關，而 N400 則反應了詞彙提取後的語意整合歷程。本研究的發現可用以支持漢字閱讀的字音提取可以發生在非常早期的階段。

關鍵詞：中文，假字，事件誘發電位，形音轉換