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Electrophysiological correlates of brand names

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ABSTRACT

EEG coherence has been used extensively in the investigation of language processing of different words categories. In contrast, relatively less is known about EEG coherence pattern of processing brand names. The present study aimed to investigate EEG coherence pattern associated with brand names in English and Chinese. EEG coherence of 32 healthy normal participants during 4 reading conditions, including concrete English words, concrete Chinese characters, English brand names and their translated Chinese brand names, were computed and compared. Regardless whether it was in English or Chinese, brand names were generally associated with higher intrahemispheric beta coherence in both the left and right hemispheres than concrete words or characters. Compared to English brand names, Chinese brand names demonstrated increased interhemispheric theta coherence in the frontal and temporal cortical regions. These results suggest that brand names tend to be processed through semantic routes. Similar to proper names and nonwords, they are represented in the lexical systems of both hemispheres. In addition, English and Chinese brand names are processed similarly at the semantic level and the difference in EEG coherence patterns associated with English and Chinese brand names is more likely due to phonological and orthographic processing that are associated with English and Chinese, respectively.

Language processing of different categories of words has been explored extensively over decades. Neuroimaging studies using functional magnetic resonance imaging (fMRI) show that distinct brain activation patterns are associated with different word categories [1,3,12,17]. Whereas conventional fMRI can identify the brain regions in which activity is associated with the task, the coherence analysis of EEG [2,9,32] provides evidence for the functional coupling between brain regions during cognitive processing. EEG coherence is a measure of linear synchronization between signals at two electrode sites as a function of frequency [22] and reflects the degree of functional cooperation between neuronal substrates [31]. Research suggests that high EEG coherence indicates strong structural or functional connection between cortical regions [28]. Given that cognitive functions, such as attention, language and memory, are subserved by interconnected neural networks in the brain [20], EEG coherence provides useful information about underlying cortical coupling and connectivity between distinct brain regions [2,9,31]. Therefore, it has been used to investigate various cognitive tasks, such as memory [18], language [31], intelligence [28] as well as brain disorders, such as Autistic Spectrum Disorder [10], Attention-Deficit/Hyperactivity Disorder [2,9], and Alzheimer's disease [16].

In relation to language processing, several studies have been carried out to study the EEG coherence patterns associated with different categories of word types [21,31–33,35]. Weiss and Mueller [31] concluded in their review paper that the coherence in the theta, alpha and beta frequency bands play important roles in the dynamic functional integration of brain structures involved in language processing of English words. Particularly, coherence increase in the theta frequency band tends to reflect non-specific components of language processing and is common for all word categories [31]. Coherence increase in higher frequency bands (over 10 Hz) is associated with more complex linguistic sub-processes, such as semantic or syntactic processing [21,32,34]. Compared to low imagery verbs, high imagery verbs are associated with increased intrahemispheric beta coherence [31]. Whereas different word categories have been explored by EEG and fMRI, brand name is a category of proper nouns that have been less understood in neuropsychological studies [11,13,14,23,24]. In the present study, we aimed to examine the electrophysiological correlates of processing brand names by EEG coherence. As brand names are known to be associated with their brand attributes, such as product quality and image, they are considered to be complicated verbal stimuli embedded with meaning that can be processed from phonological, morphological and/or semantic levels [19]. It was therefore hypothesized that brand names tended to be a category of high imagery words, demonstrating elevated intrahemispheric beta coherence, in comparison to low imagery words.

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When a company brings its products into a foreign market, one of its important decisions is to choose a brand name [30]. Research indicates that English brand names can enhance the perceived globalness of the products and are associated with the country of origin, more favorable attributes and product quality [26]. However, some studies suggest that consumers prefer brands in their own language [5,15]. Therefore, it is common for companies to use both original English names and the translated Chinese names for their brands, particularly if the products are marketed in countries with Chinese population. A challenge faced by marketers is how to translate a brand name from a phonological into a logographic system [37]. Currently, some English brand names have been translated into Chinese brand names based on phonological and/or semantic translation. With the advent of neuroimaging techniques, such as fMRI, these two language systems are generally found to be processed in distinct and overlapping regions in the brain [8,27]. It is questionable if the translated Chinese brand names are processed in a similar way as their original brand names in the brain. Therefore, another purpose of the present study was to compare any differences in the EEG coherence patterns of English brand names and their translated Chinese brand names. Due to the alphabetic and logographic system associated with English words and Chinese characters, Chinese reading shows an increased intrahemispheric theta coherence in the left hemisphere and increased interhemispheric theta coherence [7]. Therefore, it was speculated that if the neural processing of original English brand names and their translated Chinese brand names varied due to the distinct phonological and logographic systems, increased theta coherence would be found in processing Chinese brand names. On the other hand, if the difference was more related to semantic processing, the coherence pattern in higher frequency bands (over 10 Hz) would be different.

A total of 32 university students (age: 20.7 ± 0.9; years of education: 15.06 ± 0.25, grade point average: 3.11 ± 0.40, 3 males) from the Institute of Textiles and Clothing, The Hong Kong Polytechnic University, were recruited. All participants were native Cantonese-speakers who had begun to learn English before the age of 6 and had at least 12 years of education in English. They all participated voluntarily and gave informed consent in accordance to the institutional guidelines. Before the EEG recording, each participant received a screening assessment on his/her intellectual function as measured by the Test of Nonverbal Intelligence – Third Edition (TONI-III) [4]. Only participants with intellectual functioning within normal limits (TONI-III: 102.94 ± 14.97) were recruited to receive the EEG recording.

The EEG was recorded from 64 Ag/AgCl-sintered electrodes mounted in a stretch-lycra Quik-Cap (Neuroscan, El Paso, TX, USA) with electrode placement in accordance with the international 10-10 system [6]. A ground electrode was placed on the forehead anterior to Fz. The standard reference electrode of the cap, placed between Cz and CPz, was used during acquisition. Electrode impedances were under 10 kΩ and homologous sites were within 1 kΩ of each other. Signals were amplified with a Neuroscan SynAmps^2 amplifier unit (EL Paso, TX, USA) with a bandpass of 0.05–200 Hz and digitized at a sampling rate of 1000 Hz. During recording, subjects were invited to read silently 24 English words or 24 Chinese characters. Each word was presented for 5 s in four conditions: concrete English words (such as orange, dog), concrete Chinese two-character words (such as 眼睛, 報紙), English brand names (such as Giordano, Puma), and their officially used translated Chinese brand names (such as 佐丹奴, 彪馬). Concrete words or characters, which refer to the living or non-living things that can be seen, heard, felt, smelled or tasted, and are relatively low imagery words, were adapted from Cheung et al. [7,8].

The EEG data underwent offline processing for artifact removal and re-montaged the reference to linked ears using the NeuroGuide software program (NeuroGuide, v.2.5.2) as averaged earlobe reference [(A1 + A2)/2] is commonly used for EEG coherence analysis, [21,28,32–35]. Fast Fourier Transformation (FFT) was used to translate signals to the frequency domain. The EEG was analyzed over 64 electrode positions in the theta (4–8 Hz) and beta (12–25 Hz) bands as these two frequency bands are found to be associated closely with language processing and processing of word categories [31–33,35]. Coherence, defined as the spectral cross-correlation between two signals normalized by their power spectra [28,29], was calculated between all the electrode pairs, except for the eight midline electrodes (Fpz, Fz, FCz, Cz, CPz, Pz, POz, Oz). Coherence values were transformed by using Fisher's z-transform. Following published literature [2,9], the means were inverse-transformed for reporting. The coherence values were grouped into (i) intrahemispheric short-range (between adjacent electrodes pairs, such as F1–F3) or (ii) intrahemispheric long-range (at least one electrode was in between, such as F1–C1) coherence. The interhemispheric coherences were separately calculated within (iii) the frontal (Fp1–Fp2, AF3–AF4, F1–F2, F3–F4, F5–F6, F7–F8), (iv) central (FC1–FC2, FC3–FC4, FC5–FC6, C1–C2, C3–C4, C5–C6, CP1–CP2, CP3–CP4, CP5–CP6), (v) temporal (FT7–FT8, T3–T4, TP7–TP8), and (vi) parietal/occipital (P1–P2, P3–P4, P5–P6, P7–P8, PO3–PO4, PO5–PO6, PO7–PO8, O1–O2) cortical regions [7]. A significance level of $p < 0.01$ was used as a partial correction for multiple comparisons.

A Condition (concrete English words versus English brand names) × Hemisphere (Left versus Right) × Range (short versus long) repeated measures ANOVA was conducted to compare the intrahemispheric coherence in the beta frequency band. The main effect of Condition was significant between concrete English words and English brand name [$F(1, 31) = 14.890$, $p = 0.001$]. A similar significant main effect of Condition [$F(1, 31) = 18.437$, $p = 0.000$] was found in comparing the intrahemispheric beta coherence between concrete Chinese characters and translated Chinese brand names. Subsequent post hoc comparisons showed that English brand names resulted in elevated short-range [$t(31) = 3.891$, $p = 0.000$] and long-range [$t(31) = 3.002$, $p = 0.005$] beta coherence in the left hemisphere and higher short-range beta coherence in the right hemisphere [$t(31) = 2.892$, $p = 0.007$] than concrete words, whereas translated Chinese brand names had increased short-range and long-range beta coherence in both the left [short: $t(31) = 3.403$, $p = 0.002$; long: $t(31) = 3.310$, $p = 0.002$] and right [short: $t(31) = 3.104$, $p = 0.004$; long: $t(31) = 3.168$, $p = 0.003$] hemispheres, respectively (Fig. 1). Therefore, English brand names and their translated Chinese brand names generally demonstrated an increase in the intrahemispheric beta coherence within both hemispheres, compared to concrete English words or concrete Chinese characters.

For the interhemispheric theta coherence between concrete English words and English brand names, a Condition (concrete English words versus English brand names or concrete Chinese characters versus Chinese brand names) × Location (frontal, temporal, central and parietal/occipital regions) repeated measures ANOVA was performed. The interaction effect of Condition and Location [$F(3, 29) = 6.908$, $p = 0.001$] and the main effect of Condition [$F(1, 31) = 9.449$, $p = 0.004$] were significant, suggesting that there was a significant difference in the interhemispheric theta coherence between concrete English words and English brand names, and that the difference was location specific. English brand names had lower interhemispheric theta coherence in the frontal [$t(31) = 4.549$, $p = 0.000$] and temporal [$t(31) = 2.831$, $p = 0.008$] cortical regions (Fig. 2) than concrete English words. There were no significant interaction effect of Condition and Location and main effect of Condition between concrete Chinese characters and Chinese brand names in the interhemispheric theta coherence. Compared to concrete English words or concrete Chinese charac-

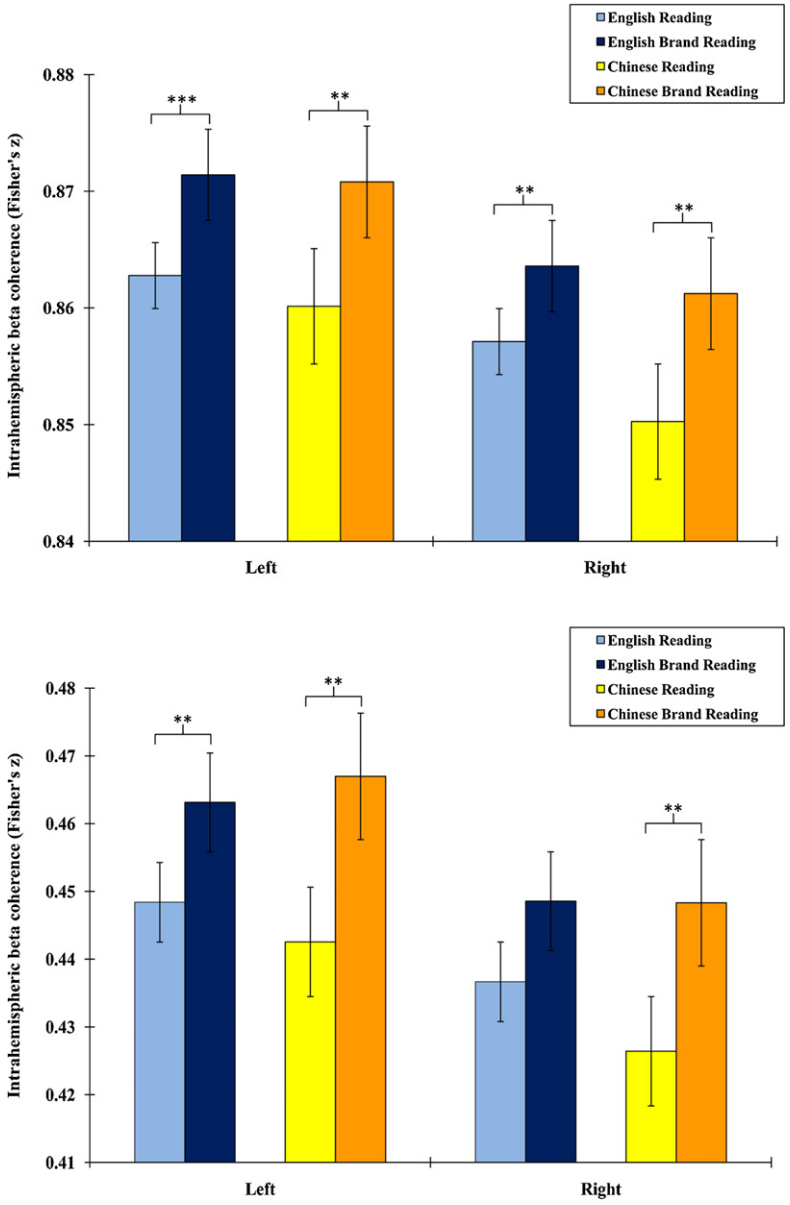

Fig. 1. Mean (inverse Fisher's z) values in the beta (12–25 Hz) frequency band for intrahemispheric (A) short-range and (B) long-range coherence. Reading brand names generally had higher beta coherence than reading concrete words/characters in the left and right hemispheres (**$p < 0.01$; ***$p < 0.001$).

ters, processing English brand names and their translated Chinese brand names did not result in any significant difference in the intrahemispheric theta coherence and interhemispheric beta coherence.

A Language (English versus Chinese) × Hemisphere (Left versus Right) × Range (short versus long) repeated measures ANOVA was performed to compare the difference in the intrahemispheric beta and theta coherence between English and Chinese brand names. The multivariate results did not show significant difference. A Language (English versus Chinese) × Location (frontal, temporal, central and parietal/occipital region) repeated measures ANOVA was conducted to compare the interhemispheric beta coherence and no significant difference was found. On the other hand, a significant main effect of Language [$F(1, 31) = 9.210$, $p = 0.005$] was found in the interhemispheric theta coherence between English and Chinese brand names. Chinese brand names generally had higher interhemispheric theta coherence than English brand names in the frontal [$t(31) = -3.088$, $p = 0.004$] and temporal [$t(31) = -3.146$, $p = 0.004$] cortical regions (Fig. 2).

Whereas different word categories have been explored by EEG and fMRI extensively, our understanding on the neural processing of brand names is relatively limited [11,13,14,23,24]. In the present study, we performed the coherence analysis of EEG to investigate the electrophysiological correlates that are involved in processing brand names and revealed several important and novel findings. Firstly, in comparison to concrete English words, reading English brand names showed increased intrahemispheric beta coherence in both the left and right hemispheres. A similar pattern of elevated intrahemispheric beta coherence was observed in reading Chinese brand names, in comparison to concrete Chinese characters. On the other hand, there was no significant difference in the intrahemispheric theta coherence between brand names and concrete words or characters. Given that coherence increase in the theta frequency band tends to reflect non-specific components of language processing and is common for all word categories [31] whereas coherence increase in higher frequency bands (over 10 Hz) is associated with more complex linguistic sub-processes, such as semantic

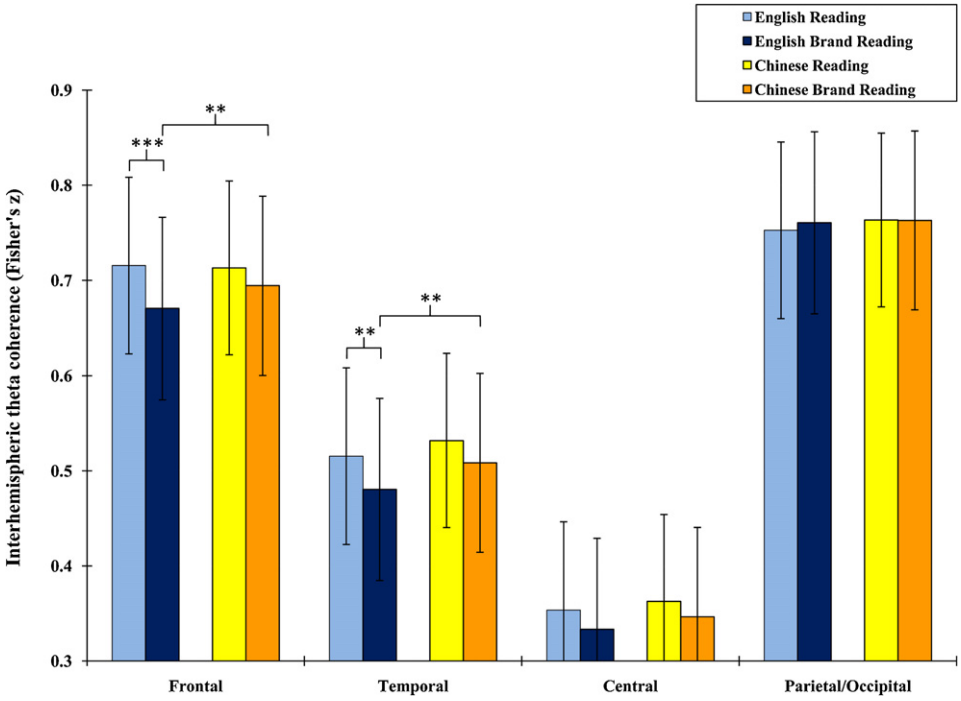

Fig. 2. Mean (inverse Fisher's z) values in the theta (4–8 Hz) frequency band for interhemispheric coherence in the frontal, temporal, central and parietal/occipital cortical regions. Compared to reading concrete English words, English brand names showed reduced theta coherence in the frontal and temporal cortical regions. Chinese brand names demonstrated increased theta coherence than English brand names in the frontal and temporal cortical regions (**$p < 0.01$; ***$p < 0.001$).

or syntactic processing [32,34], increased intrahemispheric beta coherence in reading brand names suggested that brand names, whether they were in their original English version or were translated into Chinese, tended to be processed through the semantic route. The results of the present study based on EEG coherence are generally in agreement with the case report on a patient with a semantic refractory access disorder by Crutch and Warrington [11], suggesting that brand names were grouped according to product type and processed for their semantic meaning.

There is an extensive discussion about the linguistic category of brand names. Studies that use lexical decision task (LDT) have been conducted to compare brand names with common noun and nonwords [13,14] and suggested that the hemispheric lexical status of brand names is rather mixed. Brand names behave like words in some ways and nonwords in other ways. They also seem to share some of the features of proper names [14]. In the present study, EEG coherence analysis was utilized to investigate the linguistic category of brand names because previous studies have identified the unique characteristics of beta coherence that is found to differ between word categories [31,32]. Specifically, high imagery words are shown to have higher intrahemispheric beta coherence than low imagery words whereas abstract words have higher interhemispheric beta than concrete words [31,32]. In the present study, when compared to concrete English words or concrete Chinese characters which were also low imagery words, reading brand names only resulted in elevated beta coherence within both the left and right hemispheres, but not between the hemispheres. This specific increased intrahemispheric beta coherence pattern suggested that brand names were more likely a category of high imagery words. Given that brand names are usually associated with their brand attributes, such as usage, brand position, product types and quality, we speculate that reading brand names may evoke more visual imagery and greater association with the semantic network of other attributes than concrete words or characters. The lateralization effect has also been investigated in different word categories. The involvement of the right hemisphere is observed in some categories of words, such as proper names [25] and nonwords [14]. The present study found that English brand names had elevated short-range beta coherence in the right hemisphere, and increase in both the short-range and long-range beta coherence in the right hemisphere was observed in reading Chinese brand names. Therefore, similar to proper names [25] and nonwords [14] that exhibit weaker lateralization, processing brand names involve both the left and right hemispheres, and the involvement of the right hemisphere is more prominent for processing Chinese brand names. These findings are consistent with previous studies [13,14,25] that brand names are represented in the lexical system of both hemispheres and share some linguistic features of proper names and nonwords.

Translation of brand names is considered as one of the important and complex marketing issues in international business. Given that English and Chinese belong to two different types of linguistic systems, that are, phonological and logographic, Zhang and Schmitt [36] proposed the language differential processing hypothesis in that English words are more likely to be processed by phonemes whereas Chinese characters are processed in a visual-semantic way. Comparison between EEG coherence patterns of English brand names and their translated Chinese names was finally made to investigate the transferability of brand names after translation. Similar to the difference observed in the EEG coherence patterns between English and Chinese reading [7], reading Chinese brand names resulted in higher interhemispheric theta coherence, particularly in the frontal and temporal cortical regions, than reading English brand names. Therefore, the difference in EEG coherence patterns between English and Chinese brand names is more related to the distinct phonological and orthographic processing associated with English words and Chinese characters as shown in our previous study [7]. They are processed similarly in the semantic level. One may argue that the participants may have differences in their familiarity towards English and Chinese brand names as a recent fMRI study has suggested differential frontal activation between familiar and unfamiliar brands [23]. In order to rule out

this possible factor, they were asked to read and match the translated Chinese brand names with their original English names. The percentage of correctness in reading and matching was over 90%. Therefore, increase in the interhemispheric theta coherence in the frontal and temporal regions associated with Chinese brand names did not seem to be related to the degree of familiarity. If we are familiar with the brand names, our brain will process the semantic meaning of original English brand names and the Chinese translations similarly.

This is an initial study to investigate the electrophysiological correlates in processing brand names and compare them with concrete words or characters. However, a limitation of the present study is that brand names were only compared with concrete words. Moreover, the stimuli were not controlled for syllable length. Further comparisons with other word categories, such as proper names and nonwords, with similar syllable length would shed more light about the unique neural processing pattern associated with brand names. In addition, it is unknown if unfamiliar brand names or favorite brand names will also result in a different EEG coherence pattern, which deserves investigation as these findings may provide significant information on the neural processing involved in brand selection and consumer decision making.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.neulet.2010.09.006.

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