



## Empirical study

## Development of lexical tone awareness in Chinese children with and without dyslexia

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## ABSTRACT

This paper describes two studies that examined the lexical tone awareness of Chinese children both with and without dyslexia at different primary school ages.

Study 1 examined the contributions of lexical tone awareness to distinguish children with and without dyslexia with respect to their Chinese character reading skills. Two hundred and seventy Chinese children participated in Study 1. Ninety of these were children with dyslexia (equally recruited from second, fourth, and sixth grades). Moreover, ninety children functioned as a chronological-age control group, and an additional ninety children functioned as a reading-level control group. The participants were tested for nonverbal intelligence, Chinese character reading, and cognitive-linguistic skills and lexical tone awareness. Our results revealed a later developmental ceiling in Chinese children with dyslexia than in those without dyslexia. Furthermore, children's lexical tone awareness could serve to distinguish children with dyslexia from typically developing children in all primary school years.

Study 2 compared the lexical tone awareness and Chinese character reading skills of Chinese children with dyslexia both before and after introducing the Perceptual Training Method. The participants in this study consisted of all the participants with dyslexia from Study 1, and the measurements were the Chinese character reading test and the lexical tone awareness task from Study 1. Our results revealed that only second-grade children with dyslexia gained substantially from the training on both lexical tone awareness and character naming, whereas those in the fourth grade obtained a significant improvement only on lexical tone awareness.

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## 1. Introduction

Developmental dyslexia is characterized by difficulties in word reading and spelling despite normal intelligence and adequate formal education (Catts & Kamhi, 2005; Chung, Ho, Chan, Tsang, & Lee, 2010). Much research on dyslexia demonstrated that it involves multiple cognitive-linguistic deficits; the majority of these studies focused on phonological processing, including phonological awareness, rapid automatized naming (RAN), and verbal short-term memory (STM) in most languages tested thus far (e.g., Ellis, 2014; Melby-Lervåg, Lyster, & Hulme, 2012; Wagner & Torgesen, 1987). However, in Chinese, apart from phonological awareness, RAN, and verbal STM, deficits in the awareness of another component in phonological processing,

namely, lexical tones, which are pitch patterns that signify differences in the meanings of monosyllabic words with identical phonetic segments in Chinese (Tong, Tong, & McBride-Chang, 2015), have also been linked to problems in Chinese character reading (e.g., Cheung et al., 2009; Li & Ho, 2011; Zhang et al., 2012). Given that Chinese is a tonal language, lexical tone plays a major role in conveying differences in the meanings of Mandarin Chinese words.

In Chinese, lexical tones are pitch patterns that influence different levels of language processing and are particularly related to linguistic domain (Gandour, 1978)—ranging from segmental analysis of words to suprasegmental processing of sentence structure. In natural speech, lexical tones assist listeners in distinguishing the meanings of words with identical phonetic segments and constrain syntactic interpretation. However, to date, few attempts have been made to explore the relationships between lexical tone awareness and the awareness of other components in phonological processing (i.e., phonological awareness, RAN, and verbal STM) in explaining individual differences in reading—despite the fact that reading

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has been often viewed as an execution and integration of multiple cognitive-linguistic components (Kendeou & Trevors, 2012; van den Broek & Espin, 2012; Ziegler & Goswami, 2005). To bridge this gap, a focus on lexical tone awareness would be of substantial benefit in the study of Chinese character reading among Mandarin-speaking children in Taiwan. Thus, the present paper aimed to examine the development of lexical tone awareness of Chinese children with and without dyslexia at different primary school ages.

### 1.1. Lexical tone awareness and its relationship with reading in Chinese

Lexical tone is a suprasegmental feature of the Chinese language linked to a syllable. Compared to phonemic or segmental levels of speech, including isolated vowels and consonants, features at the suprasegmental level cannot be easily analyzed as distinct segments but rather are viewed as belonging to a syllable or word, for example, prosody in English and lexical tone in Chinese (Silverman et al., 1992; Zhang & McBride-Chang, 2010). In alphabetic languages such as English, the awareness of stress in words across stress-focused phrases is a type of suprasegmental level feature, as is lexical tone in tonal languages such as Chinese (Chung, McBride-Chang, Cheung, & Wong, 2013). There are four lexical tones in Mandarin Chinese, namely, Tone 1: high level, Tone 2: high rising, Tone 3: falling-rising, and Tone 4: high falling. A syllable with different tones can represent different meanings. For example, the syllable /xi/ can represent four different meanings with four different tones: /xi1/ 西 (Western), /xi2/ 習 (study), /xi3/ 喜 (like), and /xi4/ 細 (thin).

Although there are no symbols that indicate tone in a character, an awareness of tone is important to distinguish the meaning of a syllable to identify a correct Chinese character in its contextual use, and it helps readers to distinguish homophones (e.g., both 喜 [like] and 洗 [wash] are pronounced as /xi3/) (Tong et al., 2011) and find the relationship between the pronunciation of the whole character and the phonetic radicals that convey different tones (e.g. the phonetic radical of 嬉 /xi3/ is 喜 /xi3/) (Chen, Shu, Wu, & Anderson, 2003).

Considering the functions of lexical tone reviewed above, being highly familiar with lexical tone information may enhance readers' accuracy in reading Chinese characters and learning new Chinese vocabulary (e.g., Tong et al., 2015). This view is supported by a few studies that reported the unique contribution of lexical tone awareness to reading performance with statistically controlled reading-related abilities such as phonological awareness and RAN (e.g., McBride-Chang, Tong, et al., 2008; Shu, Peng, & McBride-Chang, 2008; Tong et al., 2015). The relationships between lexical tone awareness and reading were shown to be even stronger than the association between phonemic awareness and reading in some studies (e.g., McBride-Chang, Lam, et al., 2008).

Given the importance of lexical tone awareness to Chinese reading, those faced with difficulties in reading might also perform worse on lexical tone awareness. Thus far, lexical tone awareness has been found to be important in distinguishing Chinese children with and without dyslexia in a limited number of studies.

For example, Cheung et al. (2009) found that children with dyslexia with a mean age of ten years performed significantly worse than their chronological-age (CA) control group, although not worse than a reading-level (RL) control group, on a lexical tone awareness task in which a speech continuum consisting of 5 tokens of the Cantonese syllable /xi/ realized at different frequency ranges was constructed. Similar to Cheung et al. (2009), Wang, Huss, Hämäläinen, and Goswami (2012) found that Chinese children with dyslexia with an average age of 9.9 years showed significantly

poorer performance on awareness of lexical tone than did control groups with similar reading levels (RL control group) and similar chronological ages (CA control group).

However, the group differences found by Cheung et al. (2009) and Wang et al. (2012) were not consistent with Li and Ho (2011). Although Li and Ho (2011) also found that Chinese children with dyslexia performed significantly worse than a CA control group in lexical tone awareness, no such difference was found between the group with dyslexia and an RL control group. Therefore, even though poor lexical tone awareness of Chinese children with dyslexia has been found consistently, there is still some controversy over whether a significant difference exists between lexical tone awareness of children with dyslexia and their RL group.

One of the most likely reasons for the inconsistency described above is the varying ages of the participants in the different studies. The participants with dyslexia in the studies of Cheung et al. (2009) and Wang et al. (2012) were approximately ten years old (i.e., Mean age = 10;5 and 10;0), while the RL groups in these two studies were approximately eight years old (i.e., Mean age = 8;11 and 8;6). However, in the study by Li and Ho (2011), the children with dyslexia were only approximately eight years old (i.e., Mean age = 8;11), and they used an RL group with a mean age of approximately seven (i.e., Mean age = 7;4). Considering the rapid development of brain executive functions before the end of primary school (Anderson, 2002), a difference of two years at primary school ages may cause a large developmental gap in many aspects, which might be the reason for the inconsistent findings above.

To date, only a few studies have demonstrated the developmental trajectory of lexical tone awareness in typically developing children. For instance, Ciocca and Lui (2003) compared children who were four, six, and ten years of age and adults on lexical tone awareness. They found that the development of lexical tone awareness did not extend beyond approximately ten years of age (i.e., the lexical tone awareness performance of ten-year-old children was not significantly different from that of adults), and their results have also been supported by other studies (e.g., Sze, 2004).

The findings of developments in lexical tone awareness described above are in line with the development of auditory temporal processing, which is considered to be an underlying mechanism of lexical tone awareness (Zhang & McBride-Chang, 2010). For auditory temporal processing, the previous evidence in alphabetic languages showed that typically developing children tend to reach the developmental ceiling at approximately nine years old, while children with dyslexia tend to reach levels similar to those of typically developing children by ten to eleven years of age (e.g., Hautus, Setchell, Waldie, & Kirk, 2003). This view is supported by recent studies conducted in Chinese (e.g., Wang & Yang, 2016).

Almost all studies on the role of lexical tone processing in Chinese reading have been conducted in Cantonese, which contains six contrastive lexical tones (Matthews & Yip, 1994). Although both Mandarin and Cantonese are tonal languages and are dialects of Chinese languages (Peng, Zhang, Zheng, Minett, & Wang, 2012), the lexical tone systems in Mandarin and Cantonese are diverse, which may obstruct the direct application of the results concerning the development of lexical tone awareness to the Mandarin population. Therefore, further investigation on the increasing trend in the development of lexical tone awareness as age increases is necessary for Mandarin.

In addition, the strong associations between phonological processing and Mandarin/Cantonese lexical tone awareness at different ages has been revealed by previous studies (e.g., Chen, 2001; McBride-Chang, Tong, et al., 2008; Shu et al., 2008; Tong et al., 2015; Xu, 1991), and it has also been found that the development of lexical tone awareness may be a result of the growth in metalin-

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