Effect of Musical Training on Lexical Tone Perception in Chinese Dyslexic Children

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Abstract

This study examined the effect of musical training on Cantonese lexical tone perception in Chinese dyslexics and normally developing readers. Experiment 1 compared perception of musical beats and lexical tone between normally developing children with music training and ones without music training to investigate the effect of musical training on lexical tone perception in normal children. Children with musical training performed significantly better than those without musical training in lexical tone identification and musical beats perception. Experiment 2 tested perception of lexical tone and music beats in dyslexic children with musical training, dyslexic children without musical training and normal controls without any musical training. The result showed that there was significant difference between dyslexic children without musical training and normal controls in lexical tone perception, but there was no significant difference between dyslexic children with musical training and normal controls, indicating that musical training was effective in improving lexical tone perception ability of dyslexic children. These imply that musical training could be an effective way to help dyslexic children read better.

Keywords: Music, Lexical Tone Perception, Musical Beats Perception, Dyslexia

Effect of musical training on lexical tone perception in Chinese Dyslexic children

Dyslexia is one of the specific learning disabilities, which is characterized by difficulties with reading and writing (Lam, 2009). Dyslexia is relatively common in Hong Kong and the prevalence is around 1%-11% at school age and the ratio of male to female is around 1.6:1 (Salter & Smythe, 1997, as cited in Chan, Ho, Tsang, Lee & Chung, 2007, P.250). Dyslexia causes psychological burden on dyslexic children and their parents (Ingesson, 2007). Behavioral and emotional problem, such as low esteem, will be caused if dyslexia is not identified and untreated early on (Chan, 2004). According to Chan (2004), around 61% of dyslexic children are having severe emotional and behavioral problems, compared to around 10% in general population. Therefore, early identification and treatment for dyslexia is important in order to reduce the social and economic cost caused by dyslexia. Although there are many intervention programs for training dyslexics, most programs have been focused on language or reading per se, and the effectiveness of these program is a matter of debate (Ho & Ma, 1999; Law & Wong, 2005; Zhou, McBride-Chang, Fong, Wong & Cheung, 2012). In particular, there is no study to date has examined the effect of musical training on improving the lexical tone perception in Chinese dyslexia, which is the focus of the present study.

Musical Beats Perception and Reading. There was research showing that reading was related to the perception of musical beats (Goswami, Huss, Mead, Fosker & Verney, 2012). Their study reported that accurate perception of musical beat accounted for over 40% of the variance in single word in children, which suggested non-linguistic musical beat would be a predictor of variance in reading English word. However, no studies have been done to investigate the effect of musical beats perception in Chinese

reading. Thus, in this study, we will examine the relationship between musical beats perception and Chinese word reading

Music and Lexical Tone Perception. Music and language both involves a complex uses of sound-based communication (Alexander, Wong, & Bradlow, 2005). Musical idiom and musical intonation are not simply sound but they also express feeling, often something human (Steven & Aaron, 1994). In recent years, considerable amount of researches were carried out to investigate the influence on musical training on language (Schön, Magne & Besson, 2004; Magne, Schön & Besson, 2006; Delogu, Lampis & Belardinelli, 2006; Patel & Iversen, 2007; Bidelman, Gandour & Krishnan, 2011). Perception of lexical tone in tonal languages was usually studied as a parameter of influence by music because pitch variation is a key feature in both language and music (Alexander et al., 2005; Cooper & Wang, 2010; Mok & Zuo, 2012). Both lexical tones in speech and pitch change in music involve the change of fundamental frequency. Pitch variation in tonal language, such as Cantonese, convey lexical meaning such as the syllable /si/ means poem 詩 [si1], history 史 [si2], try 試 [si3], time 時 [si4], market 市 [si5], and event 事 [si6] when speaking with six different tones. However, pitch change in music involves affective feelings, such as joy, belongingness, despair and sadness (Scherer, 2004; Baumgartnera, Lutz, Schmidt, & Jäncke, 2006). Several number of researches showed that extensive musical training can facilitate the perception of non-native lexical tone in both non-tonal language speakers (Alexander et al., 2005; Mok & Zuo, 2012) and non-native tonal language speaker (Cooper & Wang, 2010). For example, Alexander et al. (2005) showed musician group performed significantly better than the non-musician group in non-native tone identification and tone discrimination tasks.

Similar result was obtained in Cooper & Wang (2010), in which the result showed that significantly higher accuracy for non-native tonal musician in Cantonese tones identification task than that for the non-native tonal non-musician. Mok & Zuo (2012) studied the effect of musical training on Cantonese lexical tone perception in native Cantonese adult speakers, in which the results indicated that no significant differences were found between musician and non-musician group in both accuracy and reaction time in lexical tone discrimination task. However, no studies have been done to investigate the effect of musical training on the development of lexical tone perception in Cantonese children. According to Ciocca & Lui (2003), Cantonese-speaking children achieve adult performance in lexical tone perception at around age 10. It will be worthwhile to investigate if musical training can enhance the development of lexical tone perception in Cantonese children below 10. Thus, we will examine whether musical training influence young children's lexical tone perception.

Lexical tone perception in Chinese Dyslexia. There are empirical studies showing that Chinese dyslexic children were found to have poorer lexical tone perception ability than normal children (Cheung et al., 2009; Li & Ho, 2011). Cheung et al. (2009) found that Cantonese dyslexic children performed poorer in both the perception of lexical tone and aspiration than age-matched group and indicated Chinese dyslexic children have delay in lexical tone perception. Similar result was obtained in the study by Li & Ho (2011), in which the results showed that dyslexic children performed significantly worse than age-matched group in nearly all lexical tone awareness tasks. Therefore, it will be interesting to investigate whether dyslexic children with musical training can achieve the lexical tone perception ability of age-matched children without musical training.

Cogo-Moreira et al. (2012) reviewed different research studies about the use of musical training in improving reading ability in children and adolescents with dyslexia in Indo-European language. However, they concluded that no judgment of the effectiveness of music education on dyslexia could be made because none of the researchers were able to provide significant evidence due to the limitation of research design. Lexical tone perception was found to be correlated with early acquisition of Chinese characters in previous researches (Shu, Peng, & McBride-Chang, 2008; Wong, Leung & Tardif, 2008; Wong, Ciocca & Yung, 2009). Lexical tone perception is important in distinguishing speech syllable and mapping them to characters in young reader. It is therefore interesting to investigate the effect of musical training on lexical tone perception in Chinese dyslexic children. If it is found that musical training can improve the lexical tone perception in dyslexic children, we may hypothesize that musical training would be a possible early aid for children who are at risk of dyslexia.

Due to the limited number of dyslexic participants, the current study is separated into two experiments to increase the statistical power. Experiment 1 was conducted to study the effect of musical training in development of lexical tone perception in normal Cantonese-speaker children to study the effect if musical training on language in Cantonese-speaking children. This will allow better understanding of the relationship between musical training and lexical tone perception development in Cantonese. In Experiment 2, lexical tone perception of dyslexic children with and without musical training and normal children without musical training was compared so as to find out if there is deficit in lexical tone perception in Chinese dyslexic children. This may help to

identify if musical training will be a possible early aid for Chinese dyslexia because lexical tone perception was found to be related to character acquisition in Chinese.

Experiment 1

The first question of this study is to examine whether musical training will improve lexical tone perception in Cantonese-speaking children. To address this question, a battery of phonological, auditory, reading and writing test was administered.

Method

Participants. A total of forty-four Cantonese-speaking, Chinese-reading children aged from six to ten (mean age = 7;10, SD = 0.74) took part in this study. This study used a non-probability sample in which refer to the population to whom the researcher had easy access. They all spoke Cantonese as their first language and had been living in Hong Kong since birth. None of them had any other neurological or psychiatric disorders. A consent form was given to their parents to ensure their understanding about the study. Twenty of them were recruited in the music group (mean age = 8;02, SD = 0.90). All of the participants in music group had learnt one musical instrument such as violin, piano or guitar for more than 2 years on average. The remaining twenty-four participants were recruited in the non-music group (mean age = 7;07, SD = 0.55). All of the participants in the non-music group did not receive any extra musical training except from once-a-week music lesson in school with less than 1 hour musical training exposure per week.

Table 1.

Demographic Information of Participants

	Music (*N*=20)	Non-music (*N*=24)	*t* (df= 2)
Age (year; month)	8;02	7;07	47.06 *
Family income (HKD $)	33824	16739	2.96
Education level of parents (%)			
Primary Graduate	3.33	8.89	2.2
Junior Secondary Graduate	20	44.44	2.63
Senior Secondary Graduate	30	37.78	8.71
Undergraduate education (or equivalent)	16.67	7.67	2.7
Holder of Bachelor degree (or equivalent)	23.33	2.22	1.21
Postgraduate Education	6.67	0	1
Average duration of musical training (months)	27.4	0	1

Note. $*p < 0.05$

Material Design and Procedure. The participants were given a language and music background questionnaire, a non-verbal intelligence test, three Chinese word reading and dictation tests, a lexical tone identification test and a musical beats perception test. All tasks were administered individually to each participant except for Chinese dictation task. The standardized instruction and stimuli were presented to the participant over earphones broadcasted from notebook. The complete testing session for each participant lasted for approximately 60 minutes.

Language and Music Background. A language and music background questionnaire was structured with 22 questions concerning the participants' language experience and proficiency, the mother tongue of the parents, educational background of the parents, social-economic status as well as musical experience of children and their parents (See Appendix). The questionnaire was completed by the parents of participant.

Non-verbal intelligence (IQ). Raven's Standard Progressive Matrices (Raven, 1976) was carried out to assess the non-verbal intelligence of the participants. There were three sets of twelve items each. Each items consisted of a visual matrix with a missing part. Participants were asked to select a plate from six choices to complete the visual matrix.

Chinese reading and dictation. Three Chinese reading and writing subtests of HKT-SpLD (Ho, Chan, Tsang & Lee, 2000) were used, including character recognition, one minute reading and Chinese words dictation. In the character recognition subtest, there were a total of 150 two-character Chinese words arranged in ascending order of difficulty. The participants were asked to read the words aloud until they failed 15 consecutive items and one point was given for correct pronunciation of both characters in each word. In Chinese words dictation subtest, there were a total 48 two-character Chinese words and the participants were asked to dictate in ascending order of difficulties until they failed in 8 consecutive items. One point was given for each correct written Chinese character. Lastly, 90 simple two-character Chinese words were presented to participants in the one minute reading subtest. Participants were asked to read aloud as many of these words in the presented order as they could in one minute. One point was given for correct pronunciation of each item.

***Lexical tone identification*.** 6 lexical tones of the same phoneme (i.e. /ji/ and /fu/) were chosen as stimuli and a total of 12 targets were created. Each target phoneme was introduced to the participants with a corresponding picture (meaning of the word) before starting of the test. Standardized stimuli were presented over earphones broadcasted from Mac or Samsung notebook. The participants were asked to repeat the target phonemes once to ensure correct perception of instruction. There were 3 practice and 48 experimental trials. The participants were asked to identify the target word by pointing to the corresponding picture among 8 tone contrasts.

***Musical beats perception*.** This task was carried out using a computer program. There were 24 trials of different beat structure arrangements of a series of notes including in this task. Twelve of the trials were having identical series of notes twice ('identical' trials) and there was not lengthening of accented note in the 'identical' trials. Twelve of the trials were having two slightly different series of notes ("different" trials), with lengthening of the accented note by either 100 msec or 166 msec. Twelve trials (six identical, six different) were in 3 beats per bar time and twelve trials (six identical, six different) were in 4 beats per bar. The delay in the rhythm structure was either short (100 msec, six "different" trials) or long (166 msec, six "different" trials). The participants were asked to make a same-different judgment in every trial (Goswami et al., 2012). One point was given for correct judgment in each trial.

Result

Group Comparison. Table 2 showed the mean scores and standard deviations of the various tasks for the two groups of participants. The result of multivariance showed that the music group performed similarly to the non-music group in 4 tasks, namely Raven, character recognition task, Chinese word dictation task and one-minute reading task. The music group performed significantly better than the non-music group in both lexical tone identification task (F (1, 41) = 4.63, $p < 0.05$, $\eta_p^2 = 0.10$) and musical beats perception task (F (1, 41) = 6.22, $p < 0.05$, $\eta_p^2 = 0.13$), suggesting that musical-learning children performed better in pitch perception tasks but not in literacy tasks compared to non-musical learning children.

Analysis of tone contrast perception. Table 3 showed the mean score and standard deviations of the eight tone contrasts for the two groups of participants. Given that eight tone contrasts were included in the lexical tone perception task, we further investigated any difference in performance in specific tone contrasts. The result of variance showed that the music group performed significantly better only in the mid level-low level tone contrast (i.e. tone 3 versus tone 6) (F (1, 41) = 14.435, $p < 0.001$, $n_p^2 = 0.259$) than the non-music group but not in other tone contrasts including high level-high rising ($p = 0.302$), high level-mid level ($p = 0.147$), high level-low level ($p = 0.656$), high rising-low rising ($p = 0.200$), low falling-low rising ($p = .971$), low falling-low level ($p = 0.464$), low rising-low level ($p = 0.509$), This suggested that the difference in performance in identifying mid-low tone contrast contributed to the largest proportion of the difference in the identification task.

Table 2.

The Mean Scores and Standard Deviations of Raven's Standard Progressive Matrices, Character Recognition, Chinese Word Dictation, One-minute reading, Lexical Tone Identification, and Musical Beats Perception for the 2 groups; and F values for group comparison.

	Music (N =20)		Non-Music (N=24)			
Measure (max. score)	*M*	*SD*	*M*	*SD*	$F(1, 42)$	Partial Eta Sq.
Raven (36)	28.75	4.14	27.54	3.53	1.09	0.03
Character Recognition (150)	103.75	18.19	107.58	18.84	0.48	0.01
Chinese Word Dictation (96)	52.55	18.20	47.04	18.37	0.99	0.23
One-Minute Reading (90)	64.05	12.62	57.29	12.87	3.06	0.07
Lexical Tone Identification (46)	41.45	3.56	39.38	2.84	4.63*	0.10
Musical Beats Perception (24)	13.95	4.34	11.33	2.22	6.22*	0.13

Note. * $p < 0.05$

Table 3.

The Mean Scores and Standard Deviations of the 8 tone contrasts for the 2 groups; and F values for group comparison.

Tone contrast pairs (max. score)	Music (*N*=20) *M*	*SD*	Non-Music (*N*=24) *M*	*SD*	*F*(1, 42)	Partial Eta Sq.
Tone 1 vs Tone 2 (8)	5.8	0.52	5.6	0.58	1.094	0.025
Tone 1 vs Tone 3 (8)	5.1	0.91	4.6	1.17	2.18	0.049
Tone 1 vs Tone 6 (8)	5.6	0.6	5.5	0.83	0.201	0.005
Tone 2 vs Tone 5 (8)	4.8	0.95	4.4	1.17	1.695	0.039
Tone 3 vs Tone 6 (8)	5.0	1.17	3.7	1.08	14.435***	0.259
Tone 4 vs Tone 5 (8)	5.3	0.73	5.3	0.75	0.001	0.000
Tone 4 vs Tone 6 (8)	4.9	1.07	5.1	0.95	0.547	0.013
Tone 5 vs Tone 6 (8)	5.0	0.94	5.1	0.80	0.444	0.010

Note. *** $p < 0.001$

Association between lexical tone and musical beats perception with other measures. Table 4 and 5 showed the regression analysis of lexical tone identification and musical beats perception in Chinese literacy measures for the two groups. To examine the ΔR^2 of Chinese literacy measures, we conducted regression analysis by putting lexical tone identification and musical beats perception as independent variables. It was found that lexical tone identification can predict the performance in one-minute reading ($\Delta R^2 = 0.515$, $p < 0.001$) and dictation ($\Delta R^2 = 0.353$, $p < 0.01$) task only in music group. Besides, musical beats perception can also predict the performance in one-minute reading ($\Delta R^2 = 0.210$, $p < 0.05$) in music group. The result suggested that both lexical tone awareness and musical beats perception are important in Chinese word reading and writing.

Table 4.

Table of regression analysis of lexical tone identification in Reading and Writing tasks for the two groups

	Music (*N*=20)			Non-Music (*N*=24)		
Task	β	Adjusted R^2	ΔR^2	β	Adjusted R^2	ΔR^2
Character Recognition	0.338	0.065	0.114	0.167	-0.16	0.028
Chinese Word Dictation	0.569**	0.287	0.324**	0.329	0.068	0.109
One-Minute Reading	0.717***	0.488	0.515***	0.072	-0.004	0.005

Note. $^{**}p < 0.01$, $^{***}p < 0.001$

Table 5.

Table of regression analysis of musical beats perception in Reading and Writing tasks for the two groups

	Music (*N*=20)			Non-Music (*N*=24)		
Task	β	Adjusted R^2	ΔR^2	β	Adjusted R^2	ΔR^2
Character Recognition	0.279	0.026	0.078	-0.104	-0.340	0.110
Chinese Word Dictation	0.441	0.150	0.194	0.010	-0.045	0.000
One-Minute Reading	0.458*	0.166	0.210*	-0.081	-0.039	0.007

Note. *$p < 0.05$

Discussion

Effect of musical training on lexical tone identification. The present findings show that on average, music learning children have better performance in lexical tone identification and musical beats perception. The findings are similar to those previous research studies that musicians performed better than non-musicians in lexical tone perception (Schön, Magne & Besson, 2004; Alexander et al., 2005; Cooper & Wang, 2010). Wong (2007) also suggested a positive effect of long-term music exposure on lexical tone perception in native tonal speakers. However, the result constrasts the research done by Mok & Zuo (2012), in which no significant difference was found in lexical tone perception between music and non-music group. The difference may be because their participants were adult Cantonese-speakers while all participants in the current research study were children below 10 years old. According to Ciocca & Lui (2003), Cantonese-speaking children achieve adult performance in lexical tone perception at around age 10. There might be a ceiling effect of performance of adults which limits the effect of musical training in improving lexical tone perception ability. Based on the result of current research study, it is suggested that musical learning experience could enhance the lexical tone perception development and musical beats perception in normal children. One possible explanation is that there are some possible interactions between the perception mechanisms for music and linguistic tone perception and long-term music exposure may shape the linguistic sensory input circuit (Wong, Skoe, Russo, Dees & Kraus, 2007). An alternative explanation is that there is a common processing mechanism in language and music perception and a higher exposure to music increase the sensitivity of fundamental frequency detection in both music and language (Magne et al., 2006).

When analyzing the performance of the eight tone contrasts, the music group performed significantly better only in the mid-low tone contrast (i.e., tone 3 versus tone 6). This can be explained by the lexical tone perception developmental trend suggested by Ciocca & Lui (2003), in which they found that mid-low tone contrast was one of the pairs with the lowest accuracy due to the similarity in the fundamental frequency contour and small fundamental frequency difference between the 2 tones. Therefore, it may suggest that musical training helps to improve the lexical tone perception development by improving both the perceptual judgment of fundamental frequency difference and range of change in lexical tones.

Association between lexical tone and musical beats perception with other measures. It is found lexical tone identification is a predictor of both one-minute reading and Chinese word dictation tasks in music group. It suggests there are links between lexical tone awareness and literacy. Our explanation is that Cantonese is a tonal language and lexical tone awareness is important in both receptive and expressive levels in Cantonese. Cantonese-speaking children need to identify and memorize the lexical tone in learning a new word and problems in acquisition of Chinese character will arise if a child has difficulties in lexical tone identification. For example, 衣 [yi 1] (clothes) bear the same onset and rhyme as 二 [yi 6] (two) and they are only differed by lexical tone. If a child cannot identify the difference in lexical tone between the two words, the child may have difficulties in discriminating the two characters when learning. Therefore, lexical tone awareness contributes to learning to read and write a new word in Chinese. However, note that only the performance of lexical tone perception in the music group can predict the result of one-minute reading and Chinese word dictation but not in non-music group, which may imply that children in music group can take an advantage in their lexical tone awareness in learning Chinese character through a phonological strategy.

Apart from the lexical tone identification task, it is quite interesting to find that musical beats perception can also predict the performance in one-minute reading, but not on Chinese character recognition and Chinese word dictation. This is partly consistent with the finding by Goswami et al. (2012), in which they found that musical beats perception is a predictor of individual difference in reading development and suggested a possible shared neural base for both language and music. However, we cannot draw a conclusion on the direct relationship between musical beat perception abilities and Chinese literacy level in the current research as lexical tone awareness could be a common factor contributing to the statistical significance between them. Especially when it is found that the strength and significance of unique variance of musical beats perception in Chinese literacy level is smaller compared to that of lexical tone perception in Chinese literacy level.

Experiment 2

In part 1, musical training is proved to be effective in improving lexical tone perception in normal developing Cantonese-speaking children. Since lexical tone awareness is believed to be a predictor of reading development, musical training can be an early aid for dyslexic children to improve the literacy level. So, the second question of this study is to examine whether musical training will improve lexical tone perception in Cantonese-speaking dyslexic children.

Method

. **Participants and Procedure.** 10 dyslexic Cantonese-speaking children were recruited in this study. All of them were aged from six to ten and they were all recruited from a local speech clinic. 5 of them were recruited in the dyslexic music group while the remaining 5 were recruited in the dyslexic non-music group. The same battery of test in part 1 was administered and the result was also compared to 5 age- and intelligence-matched normal non-music participants in part 1. The three groups of data obtained were entered in Analysis of Variance.

Result

Group Comparison. Table 7 shows the mean scores and standard deviations of the various tasks for the three groups of participants. The results of analysis of variance (ANOVA) and post hoc comparison with Bonferroni correction showed that the normal non-music group performed significantly better than both dyslexic music group and dyslexic non-music group in three tasks, namely character recognition task (F (2, 12) = 33.9, $p < 0.001$, $n_p^2 = 0.85$), Chinese word dictation task (F (2, 12) = 34.39, $p < 0.001$, $n_p^2 = 0.85$) and one-minute reading task (F (2, 12) = 10.65, $p < 0.01$, $n_p^2 = 0.64$) while the two dyslexic groups performed similarly. In the lexical tone identification task, normal non-music group performed only significantly better than the dyslexic non-music group ($p < 0.01$) but not the dyslexic music group ($p = 0.089$). This suggested that musical-learning dyslexic children could achieve the lexical tone identification level of normal children without musical training.

Table 6.

Mean Scores and Standard Deviations of Raven's Standard Progressive Matrices, Character Recognition, Chinese Word Dictation, One-minute reading, Lexical Tone Identification, and Musical Beats Perception for the 3 groups; and F values for group comparison.

	DM (N =5)		DN (N=5)		NN (N=5)				
Measure (max. score)	*M*	SD	*M*	SD	*M*	SD	*F*(2, 12)	Partial Eta Sq.	Post hoc comparison
Raven (36)	26.2	6.02	26.4	4.16	26.0	2.12	0.01	0.002	DM = DN = NN
Character Recognition (150)	32.4	21.65	36.2	23.49	122.0	10.75	33.90***	0.850	DM, DN < NN; DM = DN
Chinese Word Dictation (96)	13.6	14.10	9.8	5.26	63.2	12.68	34.39***	0.851	DM, DN < NN; DM = DN
One-Minute Reading (90)	27.6	12.67	25.2	9.42	62.8	19.37	10.65**	0.640	DM, DN < NN; DM = DN
Lexical Tone Identification (46)	37.2	3.27	33.2	3.90	42.0	1.58	10.25**	0.631	DM, DN < NN; DM = DN
Musical Beats Perception (24)	13.4	2.88	13.4	2.77	9.8	1.64	3.54	0.371	DM = DN = NN

Note. DM = Dyslexic music group; DN = Dyslexic non-music group; NN = Normal non-music group.

$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7.

The Mean Scores and Standard Deviations of the 8 tone contrasts for the 3 groups; and F values for group comparison.

	DM (N =5)		DN (N=5)		NN (N=5)				
Measure (max. score)	*M*	SD	*M*	SD	*M*	SD	*F*(2, 12)	Partial Eta Sq.	Post hoc comparison
Tone 1 vs Tone 2 (8)	5	0.00	5.2	0.84	5.8	0.45	2.89	0.33	DM = DN = NN
Tone 1 vs Tone 3 (8)	5.2	1.10	4.6	0.55	5.2	1.10	0.67	0.10	DM = DN = NN
Tone 1 vs Tone 6 (8)	5.4	0.89	4.4	1.81	5.6	0.55	1.41	0.19	DM = DN = NN
Tone 2 vs Tone 5 (8)	4.8	0.84	4.0	0.00	5.0	0.71	3.50	0.37	DM = DN = NN
Tone 3 vs Tone 6 (8)	3.4	0.89	4.8	0.84	4.0	1.41	2.11	0.26	DM = DN = NN
Tone 4 vs Tone 5 (8)	4.8	0.84	4.0	1.59	5.6	0.55	2.74	0.10	DM = DN = NN
Tone 4 vs Tone 6 (8)	4.6	1.14	3.2	1.60	5.6	0.55	4.11*	0.41	DN < NN; DM = DN, DM = NN
Tone 5 vs Tone 6 (8)	4.0	0.71	3.0	1.00	5.2	0.45	10.71**	0.64	DN < NN; DM = DN, DM = NN

Note. DM = Dyslexic music group; DN = Dyslexic non-music group; NN = Normal non-music group.

*$p < 0.05$, ** $p < 0.01$

Analysis of tone contrast perception. Since significant difference was observed among three groups, performance of different tone contrasts were studied. Table 8 shows the mean scores and standard deviations of the 8 tone contrasts for the 3 groups. The result of variance and post hoc Bonferroni showed that the normal non-music group performed only significantly better in the low falling-low level (F (2, 12) = 4.11, $p < 0.05$, $n_p^2 = 0.41$) and low rising-low level (F (2, 12) = 5.075, $p < 0.05$, $n_p^2 = 0.110$) tone contrast (i.e., tone 4 versus tone 6 and tone 5 versus tone 6) than the dyslexic non-music group but not in dyslexic music group. This suggested that the difference in performance in identifying mid-low tone contrast and low rising-low tone contrast contributed the largest proportion of the difference in the performance of overall lexical tone identification task.

Discussion

Lexical tone identification between Normal and Dyslexic group. The present findings indicate that the lexical tone perception ability of normal non-music group is significantly better than the dyslexic non-music group, which is coherent to previous research studies that Chinese dyslexic children were found to have poorer lexical tone perception ability than normal children (Cheung et al., 2009; Li & Ho, 2011). After analyzing the performance of the 8 tone contrasts, the normal non-music group performed significantly better in the low falling-low and low rising-low tone contrasts (i.e., tone 4 versus tone 6 and tone 5 versus tone 6) than the dyslexic non-music group. In fact both tone contrasts are having similar fundamental frequency contour although the range is different. This implies that dyslexic children are having specific impairment in identifying the range of change of fundamental frequency contour. The deficits in lexical tone identification may result in a reduced tonal awareness in Chinese language, which in turn reduce their clarification of tonal information of words in their mental lexicon (Wong,

Ciocca & Yung, 2009). Tone is not explicitly represented in text in Chinese and a completely different character can be resulted by a change in tone. Therefore, an imprecise identification of lexical tone can create confusion in early acquisition of Chinese character, especially for partial homophones carrying the same phonetic radical, such as the word 馬 [ma5] (horse) and 罵 [ma6] (scold) .

Effect of musical training on lexical tone identification in Dyslexic children. In this study we found that the overall lexical tone identification ability of dyslexic music group performed similarly with the normal non-music group and no significant differences were observed in any tone contrasts. This suggested that musical training is effective in improving lexical tone identification of dyslexic children. Therefore, it is possible that music could be an early aid to improve reading and writing ability of children who are at high risk of dyslexia as we can see significant improvement in lexical tone identification in dyslexic music group when compared to dyslexic non-music group. As suggested by Siok & Fletcher (2001), lexical tone is important for Chinese word recognition and a more accurate lexical tone perception can enhance the acquisition of Chinese characters. It is because a stronger connection between orthographic and phonological representations can be built by reducing confusions between similar words due to more accurate lexical tone identification (Li, & Ho, 2007). Therefore, we may hypothesize that musical training can improve the reading and writing ability of dyslexic children by improving their lexical tone identification. A further longitudinal intervention study is recommended to investigate the efficacy of musical training in improving reading and writing in Chinese dyslexia.

Relationship between musical beats perception and Chinese literacy. It is quite surprising to find that there were no significant differences among three groups. This part of result is contradicted to the findings in Goswami et al. (2012), which suggested that non-linguistic musical beat would be a predictor of variance in reading English word. However, the current study found that musical beat perception ability of normal and dyslexic children is similar, it suggests that musical beats perception is not a factor predicting reading and writing ability in Chinese although it was found to be an predictor of reading and writing in English.

Limitation and Implication

The limitation of the study is that the small sample size reduces the statistical power of the study due to the difficulties in recruiting dyslexic participants, especially to find dyslexic children who fit the selecting criteria in music group. Therefore, a similar study to examine the effect of musical training on lexical tone perception in dyslexic children with a larger sample size is recommended. We hypothesize that musical learning may be able to improve Chinese literacy level and a further longitudinal intervention study is recommended to investigate the efficacy of musical training in improving reading and writing in Chinese dyslexia.

Conclusion

Musical learning experience was found to be effective in enhancing the lexical tone perception development in both normal and dyslexic Cantonese-speaking children. Lexical tone perception ability was found to be a strong predictor of Chinese reading and writing while musical beats perception may not be highly related to Chinese reading and writing ability when comparing musical beats perception ability between normal and dyslexic children. Musical learning can be a possible intervention strategy for Chinese dyslexia but a further longitudinal study is suggested to investigate the efficacy.

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Appendix

1. 今日日期 (日/月/年): _____

2. 填問卷者: 母親 父親 其他：_____

第一部分:

子女的資料:

3. 姓:_____ 名:_____

4. 出生日期（日／月／年）:_____ 5. 性別: _____

6. 出生國家:_____ 7. 慣用手: 左 右

8. 如果不是在香港出生，你的子女什麼時候來香港？（月/年）_____

父母的資料:

9. 請註明您家庭收入的範圍（港幣）：

_____ <10,000

_____ 10,000-20,000

_____ 20,000-30,000

_____ 30,000-40,000

_____ 40,000-50,000

_____ >50,000

請註明每位家長的最高教育水平和職業:

10. 母親

a. _____曾讀小學（未畢業）

b. _____小學畢業生

11. 父親

a. _____曾讀小學（未畢業）

b. _____小學畢業生

c. _____初中畢業生

d. _____高中畢業生

e. _____大學或學院文憑

f. _____大學或學院學位畢業生

g. _____研究生或其他專業學位

職業: _____

c. _____初中畢業生

d. _____高中畢業生

e. _____大學或學院文憑

f. _____大學或學院學位畢業生

g. _____研究生或其他專業學位

職業: _____

第二部分:

請就您的子女的語文能力回答下列問題：

1. a) 請圈出您的子女能理解的語言：

廣東話　英語　其他（請註明：_____）

您會怎樣評價您的子女對下列語言的理解呢？請圈出適當的數字。

弱　強

i. 廣東話 1 2 3 4 5

ii. 英語 1 2 3 4 5

ii. 其他（請註明：_____） 1 2 3 4 5

請大概描述您的子女對下列語言的理解：

i. 廣東話:
_____

ii. 英語:
_____

iii. 其他（請註明：_____）
_____

b) 請選出您的子女能說的語言：

廣東話　英語　其他（請註明：_____）

您會怎樣評價您的子女對下列語言的說話能力呢？請圈出適當的數字。

	弱				強
i. 廣東話	1	2	3	4	5
ii. 英語	1	2	3	4	5
ii. 其他（請註明：_____）	1	2	3	4	5

請大概描述您的子女對下列語言的說話能力：

i. 廣東話:
_____

ii. 英語:
_____

iii. 其他（請註明：_____）
_____

2. 除父母以外，您的子女有定期接觸其他照顧他／她的人（如祖父母，外傭等）嗎？有　沒有

如有，請註明他（們）跟您的子女的關係及他們說的語言。

_____

3. 除了回校上學，您的子女有參與其他語言或校外課程嗎？　有　沒有

如有，請註明課程：_____

課堂密度：　每天　每星期一次　其他（請註明：_____）

4. 您的子女的第一語言是甚麼？（如適用，請圈出多於一個語言）

廣東話　英語　其他（請註明：_____）

5. a) 如您的子女會說廣東話，他／她是何時學的？

您的子女開始學廣東話的年齡：_____

b) 您的子女在哪裡學廣東話的呢？

家中　　學校　　社區　　其他（請註明：_____）

c) 您的子女每隔多久會說廣東話呢？

每天　　每星期一次　　每月一次　　其他（請註明：_____）　不適用

請註明您的子女每天說廣東話的時間的百分比　_____%

d) 您的子女現在會在哪裡說廣東話呢？（請圈出所有適用選項）

家中　　學校　　社區　　其他（請註明：_____）

6. a) 如您的子女會說英語，他／她是何時學的？

您的子女開始學英語的年齡：_____

b) 您的子女在哪裡學英語的呢？

家中　　學校　　社區　　其他（請註明：_____）

c) 您的子女每隔多久會說英語呢？

每天　　每星期一次　　每月一次　　其他（請註明：_____）　不適用

請註明您的子女每天說英語的時間的百分比　_____%

d) 您的子女現在會在哪裡說英語呢？（請圈出所有適用選項）

家中　　學校　　社區　　其他（請註明：_____）

7. a) 如您的子女除了廣東話和英語外還會說其他語言，哪是甚麼？他／她是在哪裡學的呢？

其他語言：_____

您的子女開始學它的年齡：_____

b) 您的子女在哪裡學它的呢？

家中　　學校　　社區　　其他（請註明：_____）

c) 您的子女每隔多久會說它呢？

每天　　每星期一次　　每月一次　　其他（請註明：_____）　不適用

請註明您的子女每天說它的時間的百分比　_____%

d) 您的子女現在會在哪裡說它呢？（請圈出所有適用選項）

家中　　學校　　社區　　其他（請註明：_____）

第三部分:

我們想知道更多有關您的子女的音樂背景。請回答下列問題。

1. 您的子女曾經上過音樂班嗎？　　有　沒有

如有，請回答下列問題。（如適用，可選多於一個選項）

單獨課 _____　　小組課 _____　　學校課堂 _____

聲樂 _____　　樂器 _

課堂開始日期: _____

一星期的堂數: _____

一堂的時間: _____

您的子女在每一課之間有家練習嗎？ 有 沒有

每日練習時間：_____ 小時

受音樂訓練的總時間：_____ 月 （由九月至六月）

2. 您的子女在家中有聽音樂嗎？ 有 沒有

如有，您的子女喜歡聽甚麼類型的音樂呢？

_____

_____

3. 有家長是音樂家嗎？（專業或興趣亦可）有 沒有

如有，請描述：

_____

_____

<u>總評估：</u>

1. 總括而言，您會怎樣描述您的子女的廣東話及英語的雙語程度呢？

非雙語 不流利雙語 流利雙語

1 2 3 4 5

1 – 主要說一種語言

–只懂另一語言的少數詞彙

2 – 弱雙語

–能有限地以關鍵詞作基本對話（沒理會文法）

–需多聽一次句子才能理解

3 – 不平衡雙語

–能有作基本對話（含少數文法錯誤）

–不需多聽一次句子便能理解

–未能作流暢對話

4 – 基本雙語

–能作流暢對話

–不是每天運用第二語言

5 – 流利雙語

–能作流暢對話；每天運用兩種語言

–曾在以英國為主要語言的國家居住

研究員的判斷：_____