Cogn Process (2006) 7:203–207
DOI 10.1007/s10339-006-0146-7

LETTER TO THE EDITOR

Music-to-language transfer effect: may melodic ability improve learning of tonal languages by native nontonal speakers?

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Received: 15 March 2006 / Revised: 30 June 2006 / Accepted: 7 July 2006 / Published online: 8 August 2006

Abstract In tonal languages, as Mandarin Chinese and Thai, word meaning is partially determined by lexical tones. Previous studies suggest that lexical tones are processed by native listeners as linguistic information and not as pure tonal information. This study aims at verifying if, in nontonal languages speakers, the discrimination of lexical Mandarin tones varies in function of the melodic ability. Forty-six students with no previous experience of Mandarin or any other tonal language were presented with two short lists of spoken monosyllabic Mandarin words and invited to perform a same–different task trying to identify whether the variation were phonological or tonal. Main results show that subjects perform significantly better in identifying phonological variations rather than tonal ones and interestingly, the group with a high melodic ability (assessed by Wing subtest 3) shows a better performance exclusively in detecting tonal variations.

Keywords Lexical tone · L2 · Mandarin Chinese · Melody · Music transfer effect

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Introduction

In nontonal languages the role of pitch in verbal communication is limited to prosodic aspects working at a supra-segmental level. Tone variations inform about the interrogative-affirmative nature of the sentence, about emotional aspects of the message and other paralinguistic information.

Differently, in tonal languages, as Mandarin Chinese, lexical tones provide semantic information about a word. Mandarin Chinese has four lexical tones, traditionally labeled tones 1, 2, 3, and 4. Phonetically, tones 1–4 can be respectively described as: high-level, high-rising, low-dipping, and high-falling. A tone variation can produce a change in the meaning of a word: for example, /ma1/ means 'mother', /ma2/ means 'hemp'; /ma3/ means 'horse' and /ma4/ means 'scold' (Chao 1948).

Previous studies suggest that lexical tones are processed as linguistic information and not as a pure tonal information (Brown-Schmidt and Canseco-Gonzalez 2004; Klein et al. 2001; Van Lancker and Fromkin 1973; Wang et al. 1999). The problem of the double linguistic-tonal nature of lexical tones has been extensively faced taking into account the brain lateralization of cognitive functions. While language processing is left lateralized, the right hemisphere is argued to be dominant in the processing of musical pitch (Zatorre et al. 1992), and prosodic aspects of language (Buchanan et al. 2000).

Van Lancker and Fromkin found that Thai speakers heard better tone-words and nontonal-words at the right ear, while they show no ear effect for hums. They also found that English-speaking Ss show this right-ear effect only for nontonal-words. They concluded that

pitch discrimination is lateralized to the left hemisphere when the pitch differences are linguistically processed (Van Lancker and Fromkin 1973).

Recently Wang and collaborators found Mandarin tones being predominantly processed in the left hemisphere by native Mandarin speakers, whereas they are bilaterally processed by American English speakers without prior tone experience (Wang et al. 2001). Strong evidence for the linguistic role of pitch variations in tonal languages arrives from neuropsychological studies. Left brain damage in Thai native speakers leads to lower level of proficiency in both perception and production of lexical tones if compared with right correspondent lesions (Gandour et al. 1992).

In a PET study administered to Mandarin and English speakers, only Mandarin speakers showed additional activation in frontal, parietal, and parietooccipital regions of the left hemisphere in a perceptual lexical tone task (Klein et al. 2001).

Evidences of the linguistic nature of lexical tone processing have been also found by Brown-Schmidt and Canseco-Gonzalez (2004): they showed that N400, the event-related potential component typically elicited by unexpected linguistic stimuli, is also present in Mandarin speakers when the semantic alteration is determined by the lexical tone.

Research on categorical speech perception has offered a useful approach to address the issue of how Mandarin Chinese tones are perceived by speakers of nontonal languages.

The phenomenon of categorical speech perception has been at first shown in phoneme perception: speech stimuli intermediate between two phonemes are typically categorized as one phoneme or the other. For the same reasons, when two sounds belong to the same category it is difficult to discriminate between them (Lieberman 1957).

Categorical processing has been also demonstrated for lexical tone perception by native tonal speakers (Chan et al. 1975). It seems that while Mandarin Chinese listeners perceive lexical tones in a quasi-categorical way, nontonal speakers perceive them in a more psychophysical way finding difficulties in their discrimination (Hallé et al. 1994).

Prior experience with the tone system in one tone language may be transferable to the perception of tone in another language (Wayland and Guion 2004), while nontonal language native learners' ability to identify lexical tone contrasts can be significantly improved after a training program (Wang et al. 1999). Interestingly, learning improvements are associated with cortical modification: Wang and collaborators found that, before and after only 2 weeks of perceptual training, beginning learners of Mandarin show different activation during a lexical tone identification task. These cortical modifications involve both expansion of pre-existing language-related areas and recruitment of additional cortical regions specialized for functions similar to the new language functions (Wang et al. 2003).

The double musical and linguistic function of tonal processing induces wondering about possible transfer effects between the two domains.

Positive transfer effects from music cognition to several mental functions more and less related to music have been found [see Schellenberg (2003) for a review]. Nevertheless, the nature of the relations between music processing and other cognitive fields remains often unclear and questionable. To achieve solid and reliable results it could be useful to take into account the transfer effects involving mental functions that exhibit neuropsychological and neurophysiologic plausibility. This seems to be the case of a transfer effect from melodic to lexical tone perception. Language and music are both engaged in pitch contour analysis but differ for the nature of stimuli and for the abovementioned lateralization of brain activity.

Previous studies do not clarify if lexical tone preserves their musical nature when processed by nontonal language speakers and if musical abilities can or cannot modulate the nature of that processing. Considering the complex interplay of language and music in lexical tone processing we intend to investigate the ability of subjects with no experience of tonal languages in detecting lexical tone and phonological variations and the putative influence of music melodic skills.

Method

Participants

Forty-six university students aged between 19 and 30 years (19 male and 27 female) participated in the study. None of them had previous experience of Mandarin Chinese or any other tonal languages. All subjects presented normal sight and hearing, or corrected to normality.

Materials

Experimental materials consists of 504 monosillabic spoken words in Mandarin Chinese selected from the

Wenlin® Software for Learning Chinese. Selected stimuli were then standardized to the following features:

- Duration: 1,500 ms
- Digital format: .wav
- Sample frequency: 44,100 Hz
- Number of canals: stereo

Stimuli were organized in 72 lists of two types: listening lists and test lists. Each listening list was followed by a test list that could or could not differ from the listening list only in one of the items. The entire task consisted of five blocks of 18 pairs of listening-test lists. Lists in different blocks were of different length, starting from two items in the first block to five items in the fifth one. In each block there were six *tonal lists* in which the test lists differ from the listening ones for a tonal variation in one item only, six *phonological lists* in which test lists differ from the listening ones for a phonological variation in one item only, and six *control lists* in which listening and test lists are identical. Lists were randomized within blocks.

In order to control recency and primacy effects (Miller and Campbell 1959), lists were organized in such a way that variations could occur at the beginning, in the middle and at the end of the list with the same frequency.

Syllables were separately extracted from Wenlin software in order to avoid the problem of the tonal Sandhi.

Phonological variations were always presented with the same tone of the correspondent syllable in the listening list, in order to avoid a confusion of phonological and tonal factors. Consistently, when a tonal variation occurs, syllables in listening and in test lists remain phonologically identical.

The frequency of each possible tonal switch (e.g. from 1st to 2nd, from 3rd to 2nd etc...) was controlled.

Procedure

The administration of the linguistic test was associated with the third subtest of the Wing's *Standardized Tests of Musical Intelligence* (Wing 1948). The presentation order of the two tasks was randomized between subjects and participants were allowed to rest for a few minutes after the first one.

Melodic test

Participants were administered with the third subtest of the *Standardized Tests of Musical Intelligence* (Wing 1948). The subtest comprises 30 items. When answering each item, they must indicate whether two melodies are the same or different; if different, they had to identify the position of the single altered tone and mark it on the answer sheet. Performances were rated in terms of number of correct answers varying from 0 to 30. Participants were divided in three groups depending on how high they scored at Wing: High-Wing group, from 22 to 30; Medium-Wing group from 17 to 21 and Low-Wing group, less than 17.

Linguistic recognition task

Firstly participants familiarized with the tonal nature of the Mandarin Chinese syllables by listening and detecting tonal and phonological variations in an example set of syllables. Then subjects were presented with three training lists and finally they started the experimental session.

Subject listened to a listening list and immediately after to a test list. Participants' task was to indicate in an answer sheet if there was a phonological or a tonal or none variation between the first and the second just presented lists. They had also to indicate in which item of the list the variation occurred.

Participants were preventively informed that variations could occur only once for each list and instructed to provide an answer in any case, trying to guess when uncertain about the correct answer.

We measured subjects' performances in terms of percentage of error committed. Four types of error were considered in the analysis:

- Tonal (incorrect or missing identification of a tonal variation)
- Phonological (incorrect or missing identification of a phonological variation)
- Tonal false alarms (false recognition of a tonal variation)
- Phonological false alarms (false recognition of a phonological variation)

Results

Our first hypothesis claims that Italian speakers find more difficulty in identifying tonal variations than phonological variations. As shown in Fig. 1, errors in the identification of tonal variations (55%) were significantly more than errors in correct identification of phonological variations (17%). A within subjects ANOVA analysis shows that this difference is significant $F(1, 45) = 168.65$, $P < 0.01$.

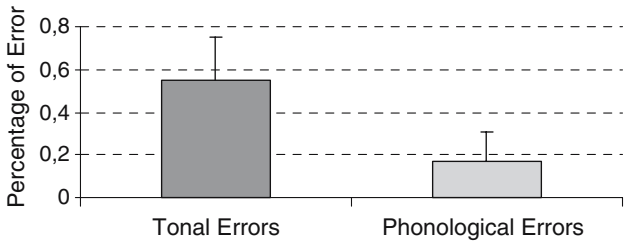

Fig. 1 Error rates in the identification of tonal and phonological variations (*bars* indicated standard deviation)

Consistently, as shown in Fig. 2, tonal false alarms were more frequent than phonological false alarms. Also in this case the within subjects ANOVA shows a significant difference between phonological and tonal performances $F(1, 45) = 58.49$, $P < 0.01$.

No influence of gender or age on the performance of participants was found.

The second goal of our investigation was to verify if the musical melodic skills influence differently phonological and tonal linguistic performances. We considered the ability in detecting melodic changes (measured by subtest 3 of WING test) as a three-levels factor in a between-subject ANOVA in which tonal and phonological percentage of errors were our dependent variables.

As shown in Fig. 3, the Wing groups differed in identifying tonal variations: $F(2, 43) = 16.85$, $P < 0.01$. More precisely, the Post-Hoc analysis (Fisher's LSD) shows that the high Wing score participants performed significantly better than the two other groups ($P < 0.01$), that did not differ in performing the tonal task ($P > 0.05$).

Differently, no differences between the groups were found in the recognition of phonological variations: $F(2, 43) = 1.11$, $P > 0.05$, nor either for tonal false alarms $F(2, 43) = 0.55$, $P < 0.05$ or for phonological false alarms; $F(2, 43) = 0.64$, $P < 0.05$.

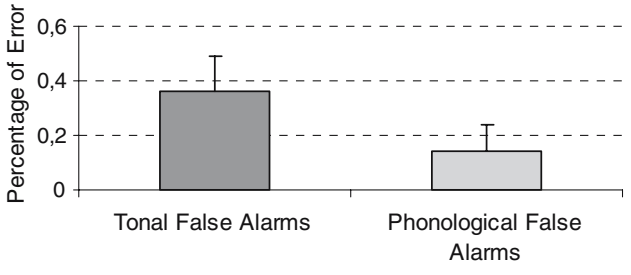

Fig. 2 Percentage of phonological and tonal false alarms (*bars* indicated standard deviation)

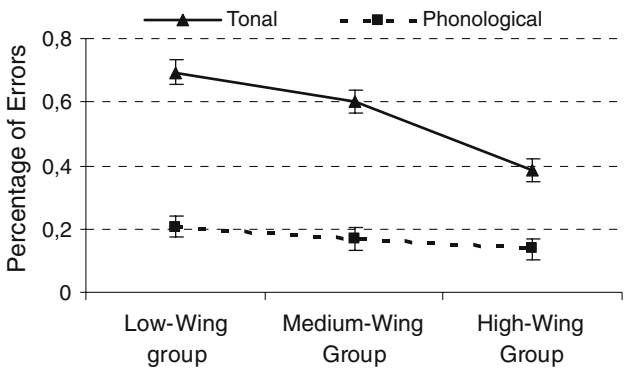

Fig. 3 Error rates in the identification of tonal and phonological variations by different Wing Groups (*bars* indicated standard error)

Discussion

One of the aims of the study was to verify if Italians speakers encounter more difficulties in identifying tonal or phonological variations in a Mandarin Chinese Syllables recognition task. Results confirmed our expectations. Participants showed a high rate of tonal discrimination errors: more than the half of the total of trials were performed incorrectly. Moreover, this difficulty was selectively limited to lexical tones discrimination and not involved phoneme discrimination. This selective difficulty is probably due to the fact that Italian is not a tonal language, and, by the consequence, lexical tones have not a lexically contrastive function for Italian speakers.

The second goal of this study was to verify if music melodic skills affect phonological and tonal perception of Mandarin Chinese syllables in naïve subjects. Also in this case, results confirmed our expectations: the only variable influenced by melodic memory is tonal discrimination, while phonological discrimination remains unaffected.

In spite of the different role of pitch variations in music and language mentioned before, it seems that a *music-to-language transfer effect* occurs.

From these considerations emerge the need of further experimentations to better clarify several aspects of the music-to-language transfer effect.

Further research would be include as a factor the specific relations between the phonological systems of L1 and L2 in order to generalize or differentiate the nature of the transfer effect. Differences in the influence of music abilities on L2 perception could be due to the distance between the sounds of L1 and L2 (Cho 2004).

Moreover, considering the abovementioned complex lateralization that characterizes music and lexical

tonal processing, further studies would be needed to assess the neural mechanisms involved.

In this pilot study we demonstrated a causal relationship between melodic perceptual ability and lexical tone discrimination performance in naïve listeners. This influence appears to be selectively focused on tonal aspects while we found phoneme discrimination unaffected by melodic proficiency.

Considering that lexical tone is essential to ascertain which one, among a variety of possible meanings, is the meaning intended by the speaker, we can conclude that it is important not to underestimate the role of the lexical tone in second language learning. It is also true that lexical tone perception is particularly hard for beginner learners with no prior experience of tonal languages. The possibility of positive transfer effect from melodic abilities to lexical tone perception is an important didactic indicator. Further researches have to be conducted to define how these cross-domain benefits could be implemented in teaching methods of tonal languages.

Acknowledgments The authors would like to thank Prof. Federico Masini and Dr. Paolo De Troia for their help in all the issues concerning the Linguistics of Mandarin Chinese.

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