

Tonal Language Processing in Congenital Amusia

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Twenty amusic and 20 control speakers of French were presented with pairs of Mandarin lexical tones to discriminate as same or different. Results revealed that even if the amusic group performed significantly below the control group, the scores of the two groups largely overlapped, with only 15% of the amusic group performing outside the normal variations. Thus, the findings suggest a modest transfer of deficit between music and speech, which in turn calls for further work in order to identify the nature of the mediating factors.

Key words: amusia; tone deafness; lexical tone perception; tonal language; pitch perception

A fundamental question that is currently hotly debated is to what extent music processing shares perceptual mechanisms with language.¹ One way to test this question is to study transfer effects between musical and language abilities, as such a transfer may be mediated by shared mechanisms. For example, Slevc and Miyake² showed that native Japanese speakers with high musical aptitude spoke English with better pronunciation than did their peers with less musical aptitude. However, since musical training improves performance on tests of musical aptitude, the positive transfer effects observed between music and language abilities could be the consequence of other factors, such as music lessons and genetic differences, rather than shared processing.³

Here we examined the transfer of *deficit* between music and language by examining the effects of impaired musical pitch perception on the discrimination of lexical tones. Musical pitch disorders characterize the condition

of congenital amusia (hereafter amusia). What distinguishes amusics from ordinary people is that they show little sensitivity to the presence of obvious pitch change in melodies.⁴ In speech, the processing of pitch information (intonation) is relatively spared, at least in the vast majority of the amusic participants tested so far in nontonal languages.^{1,5,6} This might be related to the fact that meaningful pitch variations in nontonal languages are very coarse compared to those used in music. In both English and French, meaningful pitch changes are on the order of 5–12 semitones.⁷ In contrast, Western melodies have mostly steps between consecutive notes of 1 or 2 semitones (a semitone corresponds to the smallest pitch distance used in Western music).⁸ These relatively small pitch intervals lie below the abnormally high threshold of most amusics.⁹ Hence, their pitch deficit is more likely to compromise music perception than intonation perception.¹⁰

The situation might be different in tonal languages, which use relatively small pitch changes to alter the meaning of words. In Mandarin Chinese, for example, there are four different tones,¹¹ each displaying a distinct pitch inflection trajectory: level, mid-rising,

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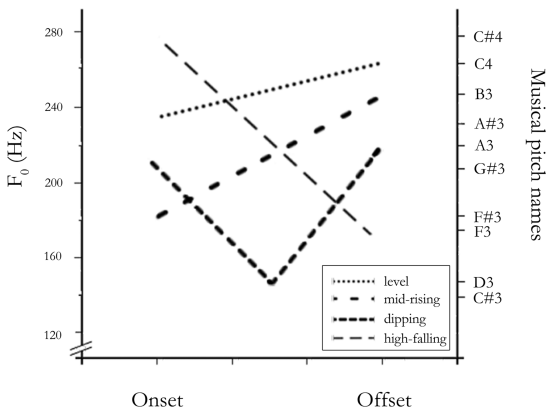


Figure 1. Representation of the four Mandarin tones used in the present study.

dipping, and high-falling. For instance, the syllable /ma/ pronounced with the level tone means “mother” while the identical syllable pronounced with the dipping tone means “horse.” The glide size (i.e., the distance between the maximum and minimum pitch height) in this level tone is less than 2 semi-tones (Fig. 1). Discrimination of such small glide sizes might be problematic for amusic individuals. The goal of the present study was to assess whether amusic individuals would be able to discriminate such pitch variations in an unfamiliar language.

Method

Participants

Twenty amusic and 20 control participants who had participated in a previous study¹² were tested in France and Canada ($n = 22$ and $n = 18$, respectively). Their global score on the Montreal Battery of Evaluation of Amusia (MBEA)¹³ was used to assign participants to either the control group (mean MBEA score = 90%, SD = 4%) or the amusic group (mean MBEA score = 66%, SD = 7%). The MBEA is a standardized diagnostic instrument designed to identify persons with disorders in music perception and memory (*amusia*). A diagnosis of amusia is indexed by an individ-

ual’s global score on the MBEA that lies 2 SD below the mean score of a reference group of normal individuals.¹³ In the present study, the 20 amusic individuals (12 women, 8 men; mean age = 48 years, range = 19–71; average duration of education = 16 years) and the 20 matched control participants (13 women, 7 men; mean age = 48 years, range = 19–73; average duration of education = 15 years) had little musical education (less than 3 years on average). None of the participants displayed any neurological or psychiatric disorder, and all had normal hearing. Participants were native French speakers, and none had prior significant exposure to tonal languages.

Stimuli and Procedure

The stimuli were 98 words spoken by a female native speaker of Mandarin Chinese, with one of the four possible tones: level, mid-rising, dipping, and high-falling tone (Fig. 1). Forty-nine pairs were built from these productions (each one used only once) with 24 pairs^c using different renditions of the same tone, and 25 pairs using different tones. A silent gap of 350 ms was inserted between tones within each pair. The different pairs contained identical phonological content and differed by the tone. For example, the syllable /long/ bore the mid-rising tone in the first word and the high-falling tone in the comparison word. Every possible combination of the four tones was presented at least twice and mixed with the “same” pairs in a random order. Randomization of the pairs was different for each participant. Stimulus presentation and response collection were done with E-Prime software.¹⁴

The word pairs were delivered through headphones to the participants, who were individually tested in a sound-attenuated booth. On each trial, participants were asked to judge whether the two Mandarin words were the same or different by pressing the appropriate

^c One pair had to be discarded because of distortion in the auditory signal.

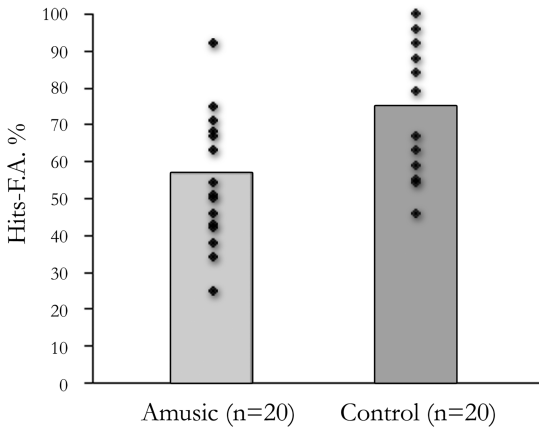


Figure 2. Mean percentage of hits minus false alarms obtained by the amusic and control groups on the Mandarin tones discrimination task. Each dot corresponds to an individual.

key on the computer keyboard. They were familiarized with the task with three example trials with feedback and continued with the 49 experimental pairs without feedback. The material and task were coming from a prior neuroimaging study with normal participants.¹⁵

Results

A “different” response to a differing pair was considered as a hit and to a same pair as a false alarm. The percentages of hits minus false alarms are presented in Figure 2. As can be seen, the amusic group performed below the matched control group [with 56% and 74%, respectively; $t(38) = -3.37$, $P = 0.002$]. However, there was a high degree of overlap between the scores obtained by amusics and controls. Only three amusics scored 2 SD below the controls’ mean. In order to examine to what extent performance on the Mandarin tone test was related to the severity of the musical disorder, performance on the Mandarin tone discrimination task was correlated with the global score obtained on the MBEA and with each of the six MBEA tests. The only test that correlated with the Mandarin tone task was the MBEA interval test, when computed both across groups

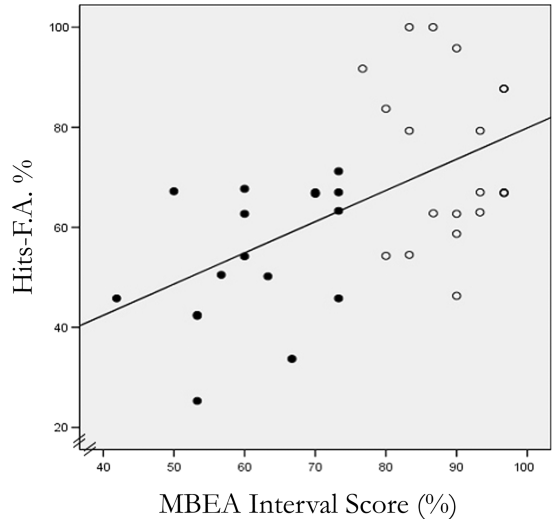


Figure 3. Individual performances on the Mandarin tones discrimination task as a function of scores on the MBEA interval test (amusics = solid circles; controls = open circles).

($r_{38} = 0.55$, $P < 0.05$; see Fig. 3) and within the amusic group ($r_{18} = 0.46$, $P < 0.05$).

Discussion

We found some support for the hypothesis that amusic speakers of nontonal languages may encounter difficulties in discriminating lexical tones and hence in acquiring fluency in tonal languages. While most amusic participants performed in the normal range, 3 of the 20 amusics (15%) were found to be impaired in the discrimination of the lexical tones. This relatively modest effect could be due to the fact that most Mandarin tones spanned more than 2 semitones (Fig. 1), which stand above most amusics’ pitch discrimination threshold.⁹ Such large pitch glides were probably coarse enough for a deficient pitch perceptual system to distinguish. Further support for the notion that music pitch perception and lexical tone discrimination could be mediated by the same (impaired) pitch perceptual system comes from the observation of a significant correlation between discrimination of Mandarin tones and discrimination of melodies that differ by interval sizes

(i.e., the interval test of the MBEA). Further work is needed to account for the nature of the common mechanisms that are able to extract pitch from speech and melodies.

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Conflicts of Interest

The authors declare no conflicts of interest.

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