Identification of Tonic in Popular and Baroque Music in Young and Older Adults Using a Dual Keyboard Apparatus

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INTRODUCTION

Tonality induction refers to the process of establishing a mental representation of the hierarchical relationship among tones in the Western European chromatic scale, during the unfolding of a musical selection. In the representation, one tone, known as the tonic, stands out as the most important tone. The key signature of notated music arbitrarily identifies the tonic but, in the first instance, tonality resides in the mind of the listener, not the musical notation. Key-finding algorithms (KFA) have been designed to predict the perceived tonic (e.g., Krumhansl, 1990; Temperley, 1999).

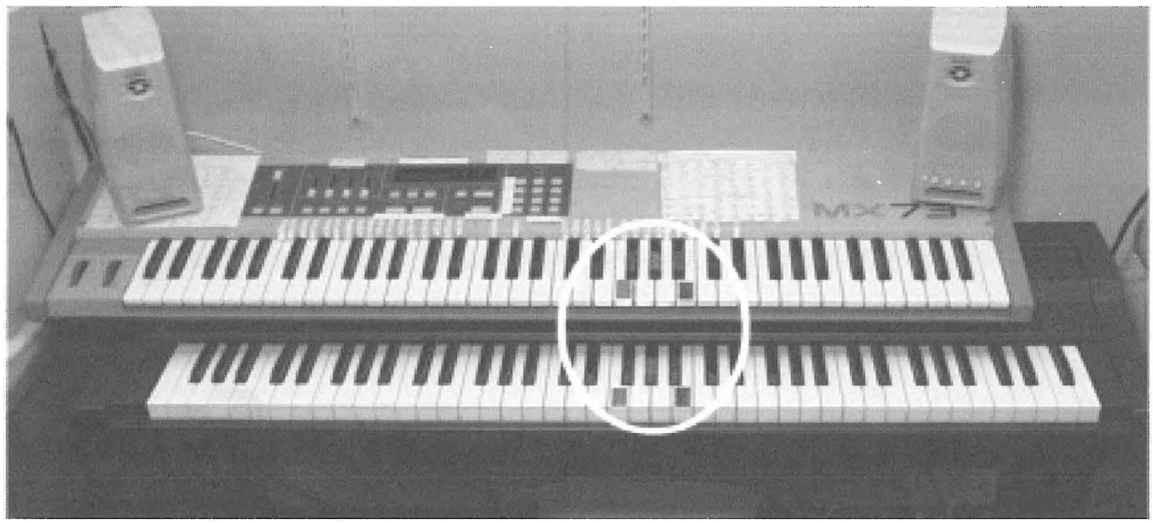
Using short excerpts from Bach's *Well-Tempered Clavier*, Cohen (1991) demonstrated high correspondence between Bach's designated key and the tonic selected by musically-trained listeners. The listeners identified the tonic by singing the first scale that came to mind that fit the excerpt. The KFA of Krumhansl also successfully identified the perceived tonic (1990, p. 84). The present study extends this investigation of tonality identification to listeners who lack musical training. Although such listeners may be able to abstract tonality as musicians do, they may have greater difficulty than musicians in singing a musical scale, hence they cannot be tested under Cohen's original vocalization procedures. To overcome this problem a method was developed by Ian Toms by which experimental subjects could explore possible tonic candidates on one keyboard and subsequently enter their choice on a second keyboard which recorded the data.

Using the dual keyboard apparatus, the present study also focussed on the role of experience in tonality induction by comparing younger and older adults on contemporary popular and classical music excerpts by Bach. While older adults would have many more years of exposure to Western-European music, their experience with recent popular music might be limited. If, as Cohen (2000) has argued, musical grammar, like language grammar, is acquired in one's youth, it is possible that the new styles represented by contemporary popular music would challenge the grammar of the older persons and make tonality induction of those pieces difficult. Specific music training of older persons might attenuate rigidity of the musical grammar representation (cf. Mainz, 2000) and enable older persons to perform equally well for classical and popular music. Conversely, young adults who would have more familiarity with popular music might be better able to induce tonality for the popular music as compared to the less familiar Baroque style.

METHOD

Subjects. There were 24 subjects representing four groups differing in age and musical training. For the younger group, mean age was 18.3 years (SD=1.3, range 16 to 20 years). For older adults, mean age was 62.8 years (SD=7.1, range 55 to 77 years). None of the untrained listeners reported any music training. Young trained listeners reported a mean of 9.7 years training (SD=2.5, range 6 to 13 years). Older trained listeners reported 31.8 mean years of training (SD. 24.2, range 3 to 68 years). The young untrained group reported listening to music 5.6 hours/week, the older untrained group reported 7.6 hours/week, the young trained group reported 19.6 hours/week and the older trained group reported 29 hours/week. All groups had equal male and female representation except for the older untrained group which had 2 males and 4 females. Several older persons reported some hearing problems but none wore a hearing aid. Audiometry for five tones (500 to 8000 Hz) was obtained for 9 older subjects and 3 young subjects and revealed poorer hearing in the older listeners especially at higher frequencies.

Music materials. There were 20 musical excerpts of approximately 10 sec in length (range 8 to 13 sec). One half of the excerpts were from the beginnings of the Preludes from the *Well-Tempered Clavier* of J. S. Bach, five from Book I and five from Book II. One half of the examples were in major keys and one half in minor. All selections achieved a score of at least .735 (mean score .88 major and .84 minor) when analysed with the KFA based on Krumhansl and Schmuckler. In all but one case (B minor, Bk II), the algorithm



agreed with the key signature of the excerpt. The exception was the musically related dominant key. Similarly, 10 excerpts of music popular in the last 1 to 30 years (mean 13 years) were chosen in major and minor keys that achieved a score 0.63 by the KFA (mean score .89 for major, and .86 for minor). Files were downloaded as MIDI files from several WWW sites. Excerpts were musically transposed from their original keys to represent tonics of F, F#, G#, A#, and B, and were converted to .wav files for access by the computer program.

Procedure. Subjects were tested individually. The concept of tonality and tonic was explained and three practice trials were presented through Altec Lansing speakers to provide familiarity with the apparatus and task. Of the three tunes used in the practice trials, two were familiar nursery tunes and one had been created specifically to represent the key; two tunes were major and one was minor. The presentations and data entry were under computer control using the Music Experiment Development System (MEDS at http://www.ethnomusic.ucla.edu/systematic/Faculty/Kendall/meds.htm) developed by Roger Kendall. Experimental trials were presented in four blocks of five trials. Each block consisted of either Baroque or popular excerpts, with major and minor modes distributed roughly equally within the block. Within a block, excerpts were randomly presented. During presentation, the subject was allowed to play (and hear) any of five colour-coded keys (F, F#, G#, A#, B) on a lower keyboard (Kawai digital piano 135) as he/she searched for the best-fitting tone. The selection was presented three times in succession and, after the third presentation, the subject played his/her chosen colour-coded tonic key on an upper "dumb" keyboard (Akai MX-73 controller) connected to the Dell Pentium 300 computer for the purpose of data entry.

Theoretical identification of tonic. A key-finding algorithm was implemented by calculating the duration of each of the 12 chromatic notes in each excerpt using software created by Temperley & Sleator (Temperley, 1999). This vector was then correlated with the 12 values from the probe-tone task for each of the chromatic tones for both major and minor keys (see Krumhansl, 1990).

RESULTS

Because there were five choices of tonic, chance performance was 20 %. For both the untrained (45.8%) and trained (74.2%) listeners, mean per cent correct identification of tonic statistically exceeded chance, t (11) = 3.7, and 8.2 respectively, both p's < .005, respectively; however, training led to higher performance. Young persons (67.5%, t = 6.2) and older adults (52.5%, t = 4.6) also performed significantly better than chance (p <.005). The further breakdown also revealed better than chance performance for all four age variable (young/old) by training variable (untrained /trained) subgroups (p < .05). Mean performance was 86.7 % (SD = 17.4) for the young trained group, 48.3 % (17.6) for the young untrained group, 61.7 % (25.0) for the trained senior group, and 43.3 % (30.5) for the untrained senior group.

The per cent correct for each of the major and minor popular and classical categories for each subject was entered into an analysis of variance having two within-subjects factors of style (classical/contemporary popular) and musical mode (major/minor), and two between-groups factors of musical training (untrained, highly trained) and age (young/older). The main effect of musical training $F(1,20) = 13.2$; $p < .005$, was statistically significant. There were no other statistically significant effects, however, this might have been attributable to the small sample size. We are in the process of increasing the sample size.

DISCUSSION

The dual-keyboard technique was successful in revealing the ability of young and older listeners to systematically induce tonality regardless of their musical or keyboard experience. Using this technique, identification of tonic was significantly above chance for all groups of listeners. There was no effect of musical style on the task. Finally, there was no significant effect of declining age on performance, although the task is associated with complex cognitive activity, and has sensory and memory components. The procedure, however, minimized memory and sensory constraints through repetition and provision of auditory feedback via the keyboard set-up.

REFERENCES

Cohen, A. J. (1991). Tonality and perception: Musical scales primed by excerpts from *The Well-Tempered Clavier* of J. S. Bach. *Psychological Research, 53*, 305-314.

Cohen, A. J. (2000). Development of tonality induction: Plasticity, exposure and training. *Music Perception, 17*, 437-459.

Krumhansl, C. (1990). *Cognitive foundations of musical pitch.* Toronto: Oxford.

Mainz, E. J. (2000). Experience-based attenuation of age-related differences in music cognition task. *Psychology and Aging, 15*, 297-312.

Temperley, D. (1999). What's key for key? The Krumhansl-Schmuckler key-finding algorithm reconsidered. *Music Perception, 17*, 65-100.

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