Proceedings of the 8th International Conference on Music Perception & Cognition, Evanston, IL, 2004
ICMPC8
S.D. Lipscomb, R. Ashley, R.O. Gjerdingen, & P. Webster (Eds.)
Adelaide, Australia: Causal Productions

ABSOLUTE MEMORY OF LEARNED MELODIES IN CHILDREN TRAINED BY THE SUZUKI VIOLIN METHOD

Victoria Saah

University of Maryland, School of Medicine

Elizabeth West Marvin

Eastman School of Music of the University of Rochester

ABSTRACT

Investigators have found that many adults without absolute pitch can reproduce a favorite song close to or in its original key without a reference tone (Levitin, 1994). This phenomenon shows a stable pitch representation for familiar melodies in adults, but we do not know whether this absolute memory for pitch exists in children. This study investigates whether children can produce a learned melody in the correct key, whether the age at which they began music study affects their accuracy, and whether showing the musical score improves performance. We chose Suzuki-method violin students because they all learn a common body of songs in fixed keys. Ten students sang six learned songs on two separate days. Their starting pitches were compared to the actual starting pitches of the songs as notated on the score, and participants' responses from Session 1 to Session 2 were compared. The major finding of this study was that participants maintained stable pitch representations from Session 1 to Session 2 that did not deviate by more than an average of 1.56 semitones. Contrary to our hypotheses, students sang within a semitone of the correct starting pitch on only 31% of the trials (below chance performance). No effects of age or of having the score visible were found.

1. BACKGROUND

Absolute pitch (AP) is defined as "the ability to identify the frequency or musical name of a specific tone, or, conversely, the ability to produce some designated frequency, frequency level, or musical pitch without comparing the note with any objective reference tone (i.e., without using relative pitch [RP])" (Ward, 1999). Nevertheless, investigators have found that many adults without absolute pitch can reproduce a favorite song close to or in its original key without a reference tone. Levitin (1994) asked forty-six undergraduate and graduate psychology students, both with and without musical backgrounds, to choose two favorite popular songs (chosen by each participant from a selection of CDs), imagine them, and then to sing them into a microphone during two trials. He hypothesized that these songs would have been heard in the same key every time the listener heard them, thus creating an objective standard against which their performance could be measured. He found that 40% of these participants sang the correct pitch on at least one of two trials. Furthermore, 81% of the participants began the song within two semitones of the correct pitch on at least one of two trials. These results suggest that the general adult population can reproduce learned melodies from a pitch memory that is relatively accurate and stable over time.

In a related study, Halpern (1989) found that when adults without absolute pitch were asked to sing familiar songs in multiple sessions, they began each song within a semitone of their previous starting pitch (SD of 1.28 semitones). Bergeson and Trehub (2002) found similar results in a study of mothers singing to their children in two sessions: the mothers began each song within a mean of 0.82 semitones of the starting pitch of their previous performance. These studies suggest that adults are able to access a stable pitch memory when singing familiar songs. But unlike Levitin's musical stimuli, which exist in codified keys on CD recordings, these songs and lullabies are learned by an oral tradition and do not have an objective standard for key and starting note.

To our knowledge, no study has similarly tested children's pitch memory in the context of melodic rote performance (as opposed to experiments that explicitly attempt to teach absolute pitch). Although one relevant study with infants showed that in nonmusical contexts, babies tend to track absolute pitch patterns and are disinterested in transposed pitch patterns (Saffran & Griepentrog, 2001). The purpose of our study was to investigate whether a stable pitch memory might exist in children who are repeatedly exposed to melodies at an objective standard pitch.

Since children hear and sing folk tunes and nursery rhymes in many different keys, the task of locating an objective standard is more difficult than it appears. To find a group of songs consistently presented in the same keys, we chose to study the specific population of children learning violin under the Suzuki method. This method emphasizes the repeated listening to and practice of beginner-level songs, reviewing them long after progressing to more difficult pieces. As a result, Suzuki students are repeatedly exposed to songs that are consistently in the same keys. We hypothesized that these students would be able to access a stable pitch memory (like Levitin's participants) and sing the songs in or close to the correct keys.

The goals of our experiment were: first, to see whether children trained in a body of specific melodies at an objective pitch standard could produce these melodies in the correct key; second, whether the age of the participants' study affected their accuracy; and third, whether viewing musical notation (upon which they were also trained) improved performance.

2. METHOD

Participants

The participants were 10 students (4 male, 6 female) at the Kanack School in Rochester, NY, who volunteered to participate with the permission of their parents. They ranged in age from 7 to 10 years (mean, 8.30; SD, 1.25) and were all right-handed. All of the students studied violin using the Suzuki method and had been playing for approximately 3 years (range 2.5 to 3.5 years). In order to investigate the effect of age at which they began instrumental study, we divided students into two age groups of 5 students each: the younger group were 6 to 8 years old (mean, 7.2; SD, 0.45) and the older were 9 to 11 years old (mean, 9.4; SD, 0.55). Thus the younger group began study at approximately 3 to 5 years of age, and the older group at 6 to 8 years.

All participants had learned the songs from Suzuki's Volume 1 and had played them consistently since their first year. These students had one of two teachers, who shared teaching methodologies. These two teachers held group classes together, which all students attended weekly and which helped ensure uniformity of instruction.

Materials

Each session was recorded on an IBM ThinkPad 2635-DEU laptop computer using the music editing program SoundForge 5.0 by Sonic Foundry. The microphone used was a Sennheiser Evolution (e) 835 S/835 vocal microphone with a frequency response range of 40 Hz to 16 kHz. It was connected to a 20-ft Monster Standard 100 microphone cable, which then connected to a 1/8-1/4 inch adapter on the computer. The distractor tones, AP test and pitch-matching test were converted from .mus files in the program Finale to .wav files in SoundForge so that the music could be played and recorded within the same program. Synthesized tones used built-in Finale timbres. These files were played through the laptop's own speakers in an isolated room. The participants' singing was also recorded in SoundForge, at a sampling rate of 44.1 kHz. After the experiment, we transferred the .wav files of their singing into the spectral analysis program Audacity, which found the fundamental frequency of each pitch. Finally, SPSS 11.0 for Windows was used to perform the statistical tests.

Stimuli

The stimuli for the experiment were six Suzuki Volume I songs, listed in Table 1 along with their starting pitches and keys. Song order was determined using a random-number table. The experiment was administered in two sessions, each followed by a post-test: a pitch-matching post-test and AP post-test.

Songs from Book I	Starting Pitch	Key
1. Go Tell Aunt Rhody	C#5	A Major
2. Minuet I	D5	G Major
3. Andantino	F#4	D Major
4. Long, Long Ago	A4	A Major
5. Allegretto	D4	D Major
6. Minuet II	G4	G Major

Table 1. Order, names, starting pitches and keys of Suzuki songs.

Post-tests: To control for differences in vocal development, we used a pitch-matching test to ensure that all participants could physically hear and sing back a given pitch pattern accurately. The pitch-matching post-test consisted of 12 pairs of notes, whose starting pitches were drawn from D4, E4, F4, G4 or A4. These pitches were chosen to represent a comfortable singing range for children and they encompass most of the starting notes of the violin pieces. These starting pitches were ordered using a random-number table. Each note lasted one second and had a synthesized violin timbre. The six intervals used were minor seconds, major seconds, minor thirds, major thirds, perfect fourths and perfect fifths. Each was heard twice, once ascending and once descending. Participants heard each two-note interval and then were asked to sing it back.

The AP post-test was made of the 18 equally tempered pitches between G3 and C5; their order was determined by a random-number table, and their timbre was a synthesized violin timbre. Each pitch was heard only once and lasted 1 second in duration. One of three distractor tone sequences was played before each pitch sounded. The distractor sequences were made up of the 12 equally tempered pitches between A3 and G#4 in a sequence that lasted a total of 1 second. Durations of the tones varied among quarter, eighth, and sixteenth note values, ordered via a random-number table. No pitch was repeated and there were no rests in the sequence.

Procedure

In two sessions a week apart, participants were asked to sing the same six songs from Suzuki's Violin Book Volume I. We recorded the sung performances to measure participants' accuracy against the objective standard, as well as their pitch consistency between sessions.

Session 1: Table 2 shows the design of the two sessions. In session 1, participants heard the first set of distractor tones, then were asked to sing song 1 (by name). Only the first few notes were recorded. The investigator stopped the student after the first few notes and repeated this process for two additional songs (songs 1, 2, 3), with distractor tones between each. Then this process was repeated for three different songs (songs 4, 5, 6). During trials 4 to 6, students viewed the score for each song individually as a potential aid to memory.

At the end of Session 1, the student was given the pitch-matching test. This test was given at the end of the session so that no tones from this test interfered with participants' recall ability or choice of starting pitch when singing the songs. For 12 trials, the participant heard an interval and then sang it back, while the investigator digitally recorded the singing.

Session 2: The second session was identical to the first, except that participants were asked to sing the last three songs first (songs 4, 5, 6), this time without the score. Then the student was asked to sing the first three songs from Session 1 (songs 1, 2, 3) with the scores visible, and those responses were recorded. (See Table 2.)

At the end of the second session, the AP post-test was performed. As before, it was given at the end of the session so that no bias was created by hearing other experimental tones. Before each pitch sounded, one of the three sets of distractor tones was played. After hearing the distractor tone sequence and then the pitch, each participant named the pitch aloud and the investigator wrote down each answer (in order to eliminate any motor skill interference by the children and also to avoid any answering bias caused by having participants see previous responses).

	SESSSION #1 Song Number	SESSION #2 Song Number
Without Notation	1 2 3	4 5 6
With Notation	4 5 6	1 2 3
	Pitchmatching Post-test	AP Post-Test

Table 2. Experimental design.

3. RESULTS

In scoring the participants' singing, only the starting pitch was evaluated. Octave errors were considered to be correct, consistent with Levitin's analysis (1994), since singers often change the octave to accommodate their vocal tessitura. Because octave errors were permitted, only pitch class was examined (not pitch height). Therefore the furthest a response could be from the correct pitch was 6 semitones. Errors by one semitone were considered correct in both the violin songs and the pitch-matching test, since these required vocal responses of the participants, and even AP possessors sometimes produce discrepant responses by one semitone (Terhardt & Ward, 1982). This method of scoring also provided some leniency for developmental issues of vocal control. Spectral analysis provided the frequency (in Hz) and decibel (dB) level of each frequency within the sung tone. Only the steady state portion of the tone was analyzed.

The major finding of this study was that participants maintained stable pitch representations from Session 1 to Session 2 that did not deviate by more than an average of 1.56 semitones. Participants consistently chose a particular starting pitch for each song, regardless of whether that pitch was near or far from the objective standard. In other words, even if the participant chose to start a song in Session 1 on a pitch that was 6 semitones away from the correct pitch, the participant usually sang that song in Session 2 near that incorrect pitch, still about 6 semitones away. Table 3 shows the average differences and standard deviations in semitones between participants' starting pitches in Sessions 1 and 2.

Average Variation of Pitch Selection between Sessions

Song	Mean Difference Between Sessions (Semitones)	SD of Difference (Semitones)
1	1.44	1.24
2	1.44	1.01
3	1.56	1.24
4	0.67	0.71
5	1.56	1.24
6	1.11	1.17

Table 3. The differences in semitones between what the participants sang in Session 1 compared to what they sang in Session 2 were averaged for each song.

Contrary to our hypothesis, participants did not sing these melodies in the key of the objective standard at above-chance levels. (Because semitone errors were permitted, we measured chance performance at 25%. Three possible correct answers of 12 possibilities yield a 3/12 or 0.25 probability of a correct answer by chance.) The participants' mean proportion correct was 31.44% (SD = 17.12%). The results of a two-tailed, one-sample t-test of their performance against 0.25 was not significant [$t(9) = 1.129$, $p<0.292$].

We hypothesized that students who began instrumental study at a younger age might have developed AP for violin tones during a critical period for acquisition, yet no effect of age was found. Levene's test for equal variances found that the variances of the two age groups did not significantly differ [$F=0.329$, $p<0.584$]. Comparing the means of the two groups with a two-tailed, independent samples t-test (33% accuracy in the younger group and 29% in the older group) revealed that the group who began study at a younger age did not identify the pitches more accurately than those who began at an older age [$t(9)=0.337$, $p<0.746$]. We also hypothesized that participants might perform better when permitted to view the score as a visual cue. However Levene's test for equal variances found no difference in the variances between the participants' performance with notation and their performance on the same melody without notation [$F=0.471$, $p<0.494$]. Comparing the means of the two groups (M=2.85 semitones away without the score and M=2.74 semitones with the score) revealed that viewing the score had no effect on accuracy [$t(108) = 0.297$, p(2-tailed)<0.767].

Post-tests: Nine of the ten participants passed the pitch-matching post-test with a mean proportion correct of 98.11%; thus we can assume that the children were developmentally able to sing a desired interval at the correct pitch. Outlier data from the tenth student, who sang only 25% of the pitches back correctly, were omitted from all data analyses.

The results of the AP post-test showed that none of the nine participants had absolute pitch. Their mean proportion correct was only 10.00%, with a standard deviation of 6.56%. Their range of accuracy was 0% to 22% of the pitches correctly identified. No semitone errors were permitted on the AP post-test (Marvin & Brinkman, 2000). Scoring results for children proved challenging: two participants stated that when they heard each given pitch, they were not familiar enough with the letter names of the notes to assign a letter to that pitch. Instead, they offered to name the fingering on the violin of where that note would be. This unfamiliarity was probably the case with some of the other students as well, even though they did not protest the naming task; many of them were hesitant with the letter names, and some exhibited a clear response bias, naming only the letters E, A, D, B and G, rather than all twelve possible note names.

4. CONCLUSIONS

Our results extend to children Halpern's 1989 and Bergeson & Trehub's 2002 findings for adults: that participants singing familiar tunes on separate occasions do so using a relatively stable key and starting pitch. One explanation for this finding may be that children and adults without AP tend to sing in a stable vocal tessitura that is comfortable for them, regardless of any objective standard in which the melody was learned. Thus the low variability in pitch may be based upon physical factors such as "muscle memory" and vocal comfort. Indeed, some children sang several melodies all in the same key, or beginning on the same starting pitch. Unlike Levitin's participants (who presumably sang along with their CDs, thus developing muscle memory for the objective-standard key), our children tended to play rather than sing these tunes and were less likely to develop a vocal muscle memory.

The finding that the children who began instrumental study at an earlier age did not perform significantly better than those who began at an older age carries implications for research on AP acquisition. Most researchers who support the early-learning hypothesis have collected data from adult AP participants and compared with non-AP participants the age at which they began musical training. In contrast, this study examined only children (who had not yet been identified as AP possessors). We did not find evidence that the children who started earlier had acquired AP. Several explanations may be posited. Our sample size may have been too small to find AP listeners. It may be that hereditary and genetic factors interact with early learning, that early training on an instrument alone is not sufficient to predict AP acquisition. Further, the confusion that some children exhibited when asked to supply note names shows that letter names had not yet been explicitly associated with pitch sounds in their minds. Finally, it may be that AP manifests itself at some threshold age, which these children had not yet reached.

5. REFERENCES

1. The authors wish to acknowledge the University of Rochester's Office of Undergraduate Research for initial funding of this project in the form of a Barth-Crapsey Award. An earlier version of this paper appeared in the University of Rochester's Journal of Undergraduate Research.

2. Bergeson, T.R., & Trehub, S.E. Absolute pitch and tempo in mothers' songs to infants. Psychological Science, 13, 72-75, 2002.
3. Halpern, A. R. Memory for the absolute pitch of familiar songs. Memory & Cognition, 17(5), 572-581, 1989.
4. Levitin, D.J. Absolute memory for musical pitch: Evidence from the production of learned melodies. Perception & Psychophysics, 56(4), 414-423, 1994.
5. Marvin, E.W., & Brinkman, A. The effect of key color and timbre on absolute pitch recognition in musical contexts. Music Perception, 18, 111-137, 2000.
6. Saffran, J.R. & Griepentrog, G.J. Absolute pitch in infant auditory learning: Evidence for developmental reorganization. Developmental Psychology, 37(1), 74-85, 2001.
7. Terhardt, E. & Ward, W.D. Recognition of musical key: Exploratory study. Journal of the Acoustical Society of America, 72, 26-33, 1982.
8. Ward, W. D. "Absolute Pitch." In D. Deutsch (ed.), The Psychology of Music (2nd ed., pp. 265-298). New York: Academic Press, 1999