ACQUISITION OF ABSOLUTE PITCH: THE QUESTION OF CRITICAL PERIODS

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Past research is reviewed which suggests that absolute pitch can be acquired during preschool years. In order to account for this phenomenon, an analogy is drawn between the early acquisition of categories for speech sounds and pitch; the acoustical similarity between vowels, music tones, and chords is also noted. Attention is then directed to a Japanese technique of Oura and Eguchi (1981) for training absolute pitch in preschool children. The technique involves identification of chords. Pilot work is reported which describes an adaptation of the first stages of the Japanese technique to eight North American preschool children and a control group of adults. The majority of the children and all adults mastered a transposed chord discrimination task but were less successful in chord identification. In contrast, Oura and Eguchi reported that Japanese children performed well on the latter task. The superior performance of the Japanese children may be attributable in part to a simpler chord training procedure and weekly piano lessons which were coordinated with their absolute pitch training program. Additional studies are therefore required to determine the viability of the chord training procedure for the acquisition of absolute pitch among North American preschool children.

Absolute pitch is the rare ability to name a music tone correctly without comparison to another (Neu, 1947). Experiential factors are thought to play a role in its development (Bachem, 1955; Costall, 1985; Cuddy, 1968; Neu, 1947; Riker, 1946). It has also been suggested that the greatest impact of experience occurs during early childhood when attention is directed to absolute as opposed to relational characteristics of sound (Sergeant & Roche, 1973).

In addition to attentional strategies that are appropriate to acquiring absolute pitch, other prerequisite auditory sensitivities are manifested at an early age. For example, six-month-old infants can imitate pitch accurately (Kessen, Levine, & Wendrich, 1979) and infants of less than one year of age can discriminate pitches differing by one semitone in untransposed (Trehub, Cohen, Thorpe, & Morrongiello, 1986) and transposed (Cohen, Trehub, & Thorpe, 1989) tone sequences. It is also during the first years of life that infants acquire the categories for the phonemes of their native language (Werker & Tees, 1984).

A parallel may be drawn between the development of categories for phonemes (vowels and consonants) and for absolute pitch. More specifically, for a particular language, many acoustically different sounds known as allophones are taken as exemplars of one phoneme. Similarly, in music, acoustically different sounds are categorized by a particular note name. For example, music instrument tones with fundamental frequency around 440 Hz might be considered allophones of the category A^4. The analogy between linguistic and pitch category development may be more applicable to vowels than to consonants. Vowels acoustically resemble pitch in that both result from simultaneous steady-state bands of different frequencies. They differ in that the frequency bands in vowels, called formants, are wide and unrelated in terms of frequency ratios; for music tones, the frequency bands are very narrow and are related by small ratios. Music chords which contain simultaneous tones also resemble both vowels and tones. Since the development of phoneme categorization occurs early in life, it is possible that categories for pitch could also form at the same time. Absolute pitch is, however, not a necessary function but phonemic categorization is necessary for language understanding. Thus, the potential to produce pitch categories may not evolve and may fail to develop from consequent disuse (cf., Ward & Burns, 1982).

Perceptual processes, therefore, may be well in place for the early acquisition of absolute pitch. Absolute pitch, however, is also a memory phenomenon. Memory capabilities of young children are thought to be lower than those of adults as a result of either poorer strategies or fewer mental resources (Case, 1972; Kail, 1984; Pascuale-Leone, 1978). Because of the dependence of absolute pitch on memory, the ability of children to acquire absolute pitch might be limited in spite of perceptual readiness.

Two independent studies nevertheless have suggested that absolute pitch can be established through appropriate training in early childhood. Grebelnik (1984) in the USSR taught nine four-year-old children 12 folk songs, each song representing one of 12 music keys. All children learned to sing each song in its appropriate key and this training transferred to identification of piano tones at a level well above chance for all children. Children who performed at a very high level on the pitch naming task were considered to have acquired absolute pitch. The technique of Grebelnik (1984) resembles and extends that of Sergeant and Roche (1973) who taught three songs to children of ages 3-4 years, 5 years, and 6 years for three weeks. In a fourth week, children were asked to reproduce the songs. The youngest age group showed significantly more evidence of remembering the absolute frequencies of the songs than did the older age groups.

A second study conducted in Japan by Oura and Eguchi (1981) claimed to develop absolute pitch ability in all children provided that the children began training at an early age, preferably before the age of five, and could not yet judge relative pitch. They employed chords as opposed to sequential presentations of notes. An essential prerequisite to the Japanese technique was therefore the absolute identification of three-note chords.

The present authors conducted a preliminary examination of the feasibility of the initial stages of the Japanese training technique in a North American setting.

Method

Eight children from the Dalhousie University Children's Centre participated. At the beginning of the study, their ages ranged from 2 years, 10 months to 4 years, 11 months. Four of the children had had extracurricular music experiences, the remainder had had none. Four adults ranging in age from 22 to 27 years participated

as volunteers from a university music class for music nonmajors. Two had six or more years of training on a music instrument. None of the subjects could provide the names of tones when tested for absolute pitch prior to the study.

Following Oura and Eguchi (1981), flags were made of dowels and colored felt, one flag for each chord to be learned. A picture for each note of the chord was placed on each flag (e.g., cat for C). In a session, the experimenter sat at a Kawai electronic piano, tuned to $A^4 = 440$ Hz, facing the child on the other side. The subject was told that he or she would hear three notes played concurrently and that the pictures on the flag were the names of the presented notes. The subject was to identify a chord by raising the appropriate flag. Subjects were trained individually three times a week for approximately 5 to10 minutes each session. The experimenter recorded each response. In accordance with the Japanese study, the chords CEG, CFA and BDG were taught in order in five stages as follows:

Stage 1: Discrimination of CEG. At the beginning of the session, the experimenter played the CEG chord in each of five octaves. The subject was told that the chord was represented by the orange flag with the cat (C), elephant (E) and ghost (G) on it. The subject held this flag as the five example chords were played and then was questioned for understanding of the concept.

After the initial chord presentation the subject received a random sequence of 15 CEG chords and five incorrect triads, providing more exposure to the chord being trained than any other. The incorrect triad consisted of notes which were not included in the CEG chord and were not major triads. The orange flag was to be waved every time the CEG chord was heard and the subject was either to keep the flag stationary or to say "no" if an incorrect sound was heard. Verbal feedback regarding correctness of response was given. Similar sessions of 20 chord presentations were conducted on five successive training days or less if the arbitrary criterion correct identification score of 80% on CEG chords and 80% on non-CEG chords was reached earlier.

Stage 2: Discrimination of CFA. Subjects were trained on chord CFA with the same procedures as described for Stage 1, but with a green flag representing CFA. Both the green flag and the orange flag were present during this stage but only the green flag was used.

Stage 3: Forced choice identification of CEG and CFA. To determine whether the subjects could distinguish the transposed chords CEG and CFA, ten CEG chords and ten CFA chords were played in a random order and the subject was to choose the appropriate flag. After each response, feedback was given. The task was repeated for five days.

Stage 4: Discrimination of BDG. Using the same technique as in Stages 1 and 2, the chord BDG was introduced and was represented by a yellow flag.

Stage 5: Forced choice identification of GEC, CFA, BDG. Twenty-one chords, seven each of CEG, CFA, and BDG, were played over five octaves and in random order. The subjects were to wave the yellow, orange, or green flag. This task was conducted for only two trial days due to time constraints.

Results

Trials to Criterion for Individual Chords: Stages 1, 2, and 4

All four adults, three of the four musically experienced children and none of the musically inexperienced children discriminated CEG at or beyond the 80% criterion within 4 or 5 days of training. Discrimination performance for CFA was similar to that for CEG although, in general, the criterion was reached one day sooner. For GBD, all experienced children achieved criterion in 4 or 5 days. None of the inexperienced children achieved the criterion in five days, but two who were performing close to criterion by the fifth day did so on a sixth day. All adults reached criterion in 4 days.

Forced-Choice Identification: Stages 3 and 5

In Stage 3, the average performance in identification of CEG and FAC over the five days was little above chance for the children (.56 for both experienced and inexperienced children) and only slightly higher for the adults (.61). Therefore, for the subjects who earlier had attained the criterion of 80% or higher on chord discrimination, identification of the two chords was more difficult. The distinction between the experienced and inexperienced children was no longer apparent. Two untrained adults each scored at chance (.52) and the two trained adults performed at a higher level (.68 and .71).

In Stage 5, the test of identification of the three triads CEG, CFA and BDG in the same session over the two consecutive days was extremely difficult. Performance was close to chance (33%) for all subjects but one musically trained adult who performed at a level of 55%.

Discussion

In four or five 10-minute sessions, many preschool children learned to classify different octave transpositions of a major chord as distinct from other chords. Musically experienced children had an advantage over inexperienced children in this task but their advantage did not extend to forced-choice absolute identification of chords. In this second task, all children performed poorly. Finally, no marked superiority of adults over children was demonstrated, especially for adults who had no music training.

In accounting for the discrepancy between the poor performance in chord identification in the present study and the high success rate reported for the Japanese study, it must first be appreciated that the present study was conducted three times a week in contrast to the Japanese study. In Japan, the training was conducted in principle, everyday: one day a week by the music teacher at a music lesson and six days a week by the mother at home.[1] Second, the Japanese and Canadian methods differed in detail. For example, Oura and Eguchi did not transpose chords in the training session in contrast to the present transposition task. Nor did the Japanese task include non-exemplars of chords in training days.[1] In Japan, the children were required to name the notes (pictographs) on each flag for each response; in the present study, the children simply raised the flag. As well, acoustic pianos were used in Japan but an electronic piano was used in the present study. Possibly the

acoustic instrument offered more unique features of individual notes in terms of harmonics and resonance. Finally, and perhaps most importantly, the Japanese children were taking piano lessons which were coordinated with this training program. In one 30-minute weekly lesson the Japanese preschoolers learned to associate pictographs with piano notes. They learned to play short melodies written with these pictographs using pictograph labels on the piano keys (Oura, personal communication, April, 1990).[1] The Canadian children were not yet involved in music performance lessons. Early piano training in Japan has also been linked by Miyazaki (1988) to the acquisition of absolute pitch (cf., Sergeant, 1969). It is then unclear as to what part of the Japanese training program contributed most to the success of the method. We know however that the present more difficult program involving only chord discrimination and identification does not lead to the same success.

Recognition of the equivalence of chords under octave transposition in the present study can be accomplished by retention of either absolute or relational information about a *family of frequencies*. The lack of transfer to chord identification tasks suggests that the original success depended on sensitivity to the relational information of major quality which could not act as a cue in the CEG/FAC identification task in which only major chords were presented. This account is consistent with other evidence of preschooler's sensitivity to chord quality (e.g., Trehub et al., 1986).

It is nevertheless possible that through the simple training/testing procedure of Oura and Eguchi (1981), templates would form representing the three note-class combinations (e.g., for CEG a representation of all octaves of C, of E and of G). With additional training, a perceived overlap in such templates (e.g., C is a member of both CEG and CFA) could lead to the differentiation of subsidiary templates for individual notes, i.e., one for C, one for E, one for G, etc. This might be best achieved through identification tasks involving chord inversions, a subsequent training stage of Oura and Eguchi's technique not reached in the present study. The identification of inversions may enhance the differentiation of individual tones of the complex (i.e., C differs from E and from G). Such independent templates could subsequently be linked to note names and consequently support absolute pitch. The neural plasticity necessary for this might be present only when the child is learning the categories for speech sounds of his/her native language. In particular, the processes required by vowel categorization may serve a role in the development of pitch categories and associated templates. The existence of established templates in people who possess absolute pitch is consistent with the findings of Klein, Coles, and Donchin (1984) who report that adults with absolute pitch do not show an evoked potential expectancy "P300" wave in the "oddball" paradigm using pitch.

The present study sets the stage for further exploration of the Japanese technique with North American preschool children. In light of the few subjects examined, any conclusions must be made with caution and the present findings must be regarded as tentative. In the future, the simpler chord training procedure which did not involve transposition should be investigated. Further, a comparison should be made between children who receive coordinated weekly piano lessons versus those who receive only chord training. Consistent with the studies by Grebelnik (1984), Oura and Eguchi (1981) and Sergeant and Roche (1973), children of the ages three to four should be targeted for longitudinal study. Such studies could have important implications for critical periods in music training and for understanding perceptual and cognitive development in general.

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Footnote

[1]These details were not available in the original report of Oura and Eguchi (1981). We are grateful to Professor Oura for providing this additional information through correspondence of April, 1990.