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MOORE, MILDRED JANE: Effect of Training on Frequency Discrimination in Primary School Children. (1971) Directed by: Dr. David R. Soderquist. Pp. 36.

A review of literature on auditory DLs in children reveals scant empirical data in contrast with adult experimentation. The present study, consequently, was designed to measure auditory DLs in 5-, 7-, and 9-year old children, 18 Ss per age group. Using the method of constant stimuli, each child's binaural DL was measured in a test, training, retest paradigm. The range of stimuli for the 5-, 7-, and 9-year olds, respectively, was 200 to 400 Hz in 10 Hz steps, 250 to 350 Hz in 5 Hz steps, and 280 to 320 Hz in 2 Hz steps with the standard tone for all groups being 300 Hz. Pretraining sessions were necessary for the 5-year old group to develop the concept of "high" and "low".

An experimental group of 9 Ss from each age level was randomly selected and given 6 days of frequency discrimination training with feedback. After training, all 54 Ss were retested using the same stimuli as in the testing sessions. The DL for the test and retest was based on three sessions of 100 trials each. A follow-up study was also conducted using the 7-year old Ss approximately 11 months later.

The results indicate: (1) DLs, prior to training, were significantly different among the age groups; (2) training significantly reduced the DL for all age groups; (3) DLs, after training, were not significantly different among the age groups; (4) DLs decreased as a function of time and experimental Ss remained superior to the controls in their ability to discriminate frequencies.

The results suggest that a child's musical abilities may be improved as a result of frequency discrimination training. The relationship between speech discrimination and frequency discrimination was also discussed.

EFFECT OF TRAINING ON FREQUENCY DISCRIMINATION

IN PRIMARY SCHOOL CHILDREN

by

Mildred Jane Moore

A Thesis Submitted to
the Faculty of the Graduate School at
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Approved by

D. R. Soderquist
Thesis Adviser

APPROVAL SHEET

This thesis has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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April 1, 1971
Date of Examination

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INTRODUCTION

Frequency discrimination is defined as the capacity to discriminate differences in frequency between tones. In some simple frequency discrimination tests, a standard tone and a comparison tone are given, and S responds by saying whether the comparison tone is "higher" or "lower". From such data a difference threshold or difference limen (DL) is computed which yields a value that measures the minimum frequency difference S can discriminate. This just noticeable difference or difference limen is the frequency change in a tone which is perceived 50 percent of the time.

Literature concerned with the topic of frequency discrimination reveals many empirical studies on auditory difference thresholds for adults. For example, the classic study by Shower and Biddulph (1931) showed DLs for adults as a function of frequency over the frequency spectrum of 31 to 11,700 Hz. In contrast, however, with the multitude of quantitative studies extant on adults, empirical investigations of frequency discrimination in infants or young children are scant. The data which are available on auditory DLs in infants are general in nature and somewhat conflicting in terms of whether an infant can discriminate gross differences in frequency. Likewise, the available information on auditory DLs in young children (3- to 8-years old) is also of a limited nature. Few studies have been reported which indicate the DLs across the frequency spectrum for young children or indicate the range of DLs for specific ages.

A large proportion of literature on DLs uses the term pitch discrimination to refer to what is actually frequency discrimination. These studies are not measuring pitch discrimination but rather are measuring S's ability to discriminate the physical change in the stimulus, or frequency discrimination (Hirsh, 1952). All studies reviewed will be discussed in terms of frequency discrimination.

Seashore (1938) stated that frequency discrimination of tones is an innate ability which cannot be altered through training. Training does not improve the capacity of the sense organ. "Training, like maturation, results in the conscious recognition of the nature of pitch, its meaning, and the development of habits of use in musical operations [Seashore, 1938, p. 58]." Wolner and Pyle (1933), however, studied seven children in grades five, six, and seven who, before training, could not discriminate 30 vibration differences on Whipple forks ranging from 435 to 465 Hz and on the piano could not discriminate octaves, fifths, thirds, or half-tones. They trained these children for 81 days (approximately 16 hours) and the results indicated that learning was an important factor in the development of frequency discrimination. After training, all seven children improved in their ability to discriminate frequencies.

Pratt, Nelson, and Sun (1930), using a coffee can, snapper, electric bell, Chinese wooden bell, and a tuning fork as stimuli, studied infants' responsiveness to sound. Only approximate estimations were made concerning the frequency and intensity of the stimuli. The loudest stimulus was the coffee can and the weakest, the tuning fork. The approximate frequencies of the stimuli included the tuning fork at 350 Hz, the electric bell with dominant frequencies between 600 and 800 Hz, and the Chinese wooden bell with dominant frequencies between 1500 and 2000 Hz. No frequency estimations could be made for the coffee can or snapper. Using 59 infants ranging from birth to 21 days and by observing eye movements and bodily reactions from a stabilimeter, the investigators concluded that infants were responsive to the stimuli but were not responsive to differences among the stimuli. Thus, they were not sensitive to differences in frequency and/or intensity. Stubbs (1934) also found that infants between 1 and 10 days old did not respond differentially to stimuli of different frequency. She presented pure tones through a speaker binaurally to 75 infants. The stimuli, each of 10 seconds duration, included 128, 256, 1024, and 4096 Hz. Each stimulus was presented at 20, 35, and 50 sensation units. By observing bodily activities from a stabilimeter and respiration from a pneumograph, Stubbs concluded that infants 1 to 10 days old are responsive to sounds but do not respond differentially to sounds of differing frequencies.

In contrast with the above studies, there is conflicting literature on the subject of DLs in infants which indicates that infants ranging from birth to 4 months may discriminate differences in frequency. Hutt (1968) measured the EEG, EMG, eye movements and heart rate of 12 infants 3 to 8 days old. Presenting monaural square wave and sine wave tones of 125, 250, 500, 1000, and 2000 Hz calibrated at a sound pressure level of 75 dB, Hutt concluded that the infants were responsive to frequency. He also found that the responses to the square wave and sine wave stimuli of 125 and 250 Hz were significantly greater than those to the other stimuli. Hutt hypothesized that, physiologically, this greater excitation to the lower frequency stimuli was a result of the displacement over a greater length of the basilar membrane. He concluded that the evidence tends to indicate that the human cochlea may be fully mature at birth (Bast and Anson, 1949). Further evidence of the maturity of the human cochlea was shown by Leventhal and Lipsitt (1964). Using 64 infants ranging in age from 1 to 4 days who were first adapted to a 10 second tone, they recorded respiration from an infant pneumograph and body movements from a stabilimeter. One-half of Ss received a 75 dB square wave tone of 200 Hz while other Ss received a 500 Hz tone presented through a 6 inch speaker placed 1 foot from the ear. One-half of each group was stimulated at the right ear and the other one-half at the left ear. To test for discrimination, one-half of Ss who had been tested originally on 200 Hz were tested on 500 Hz and vice versa. Using a two and one-half inch speaker placed 6 inches from the ear, the same procedures were repeated using stimuli of 200 and 1000 Hz. Their data, which approached significance (at the .05 level), indicated that some infants could discriminate between 200 and 1000 Hz and between 200 and 500 Hz. Bridger (1961) recorded heart rate in 50 infants ranging from 1 to 5 days old. Using a procedure similar to Leventhal and Lipsitt (1964), he habituated the infants to a pure tone of 400 Hz and then presented the 1000 Hz tone. The stimulus was intense enough to obtain a response (i.e., not calibrated in SPL). Then the procedure was reversed with the infants first being habituated to the 1000 Hz tone and then presented the 400 Hz tone. A startle reaction as well as an accompanying increase in heart rate was observed in 15 Ss, indicating that some infants could possibly discriminate between 400 and 1000 Hz. In an earlier study by Kasatkin and Levikova (1935), it was found that three infants two and one-half months old could be classically conditioned to respond to a tone of approximately 640 Hz by pairing a feeding bottle (UCS) with the 640 Hz tone sounded from an organ (CS). After several pairings, a sucking response was elicited when the organ was sounded alone. The number of pairings differed for each infant tested. After this conditioned reflex was established, they sounded a 168 Hz tone without pairing with the bottle and found the infants also gave a sucking response to this tone. After several presentations of this stimulus, these infants ceased responding to the 168 Hz tone. Thus, by the time they were three and one-half months old, they could discriminate between 168 and 640 Hz. Using the same procedure, they found that by the time the infants were 4 months, 4 days, they could discriminate between approximately 336 and 640 Hz, indicating that either learning and/or maturation had increased the capability of the infants to discriminate.

In summary, the data seem to indicate that very young infants (birth to 4 months) have a limited ability to discriminate frequency. It also appears that at birth the neurophysiological structures for auditory discrimination may be available, but not fully mature. This neural immaturity may possibly limit frequency discrimination ability of young infants to a range of approximately 300 to 600 Hz.

Although a few studies are available on young infants, there appears to be no literature on frequency discrimination for infants between the ages of 4 months to 3 years. There are some relevant studies, however, which report the DLs of children between 3 and 8 years of age.

Repina (1961), in a series of studies conducted in Russia, measured the DL of children 3 to 7 years of age. The DLs ranged from 25 to 170 Hz measured at a standard of 500 Hz. The exact procedures and intensities were not reported, although some didactic games were used with the younger children to develop the concept of "high" and "low". Repina concluded that the magnitude of the threshold was dependent upon the nature of the methodology used with the age groups. Duell and Anderson (1967) reported the DLs in a free field situation of 168 _S_s ranging in age from 6 to 8 years. Using a changing standard technique (both standards and comparisons ranged from 390 to 440 Hz in 5 Hz steps), _S_s were instructed to judge only whether the stimuli were the same or different. They reported DLs of approximately 42, 30, and 16 Hz for 6-, 7-, and 8-year olds, respectively. Thus, their data showed an improvement in frequency discrimination ability with age.

Although the data reported in literature for young children and infants are not in abundance, some trends exist. First, the data show that DLs for children are larger than DLs for adults. Second, the DL seems to be a function of age; that is, the DL decreases with increasing age. Third, the data reported indicate that frequency discrimination may be improved through specific training.

The review and discussion of literature suggest four hypotheses concerning frequency discrimination in primary age children. First, DLs prior to training will show a tendency to decrease as a function of age.

Second, children trained in frequency discrimination will have significantly smaller DLs in comparison with children who receive no training. Third, frequency discrimination will improve (DLs will decrease) for each of three different age levels (5, 7, and 9 years) as a function of training and will be equivalent for all age levels. Fourth, DLs will decrease as a function of time and trained Ss will remain superior to untrained Ss. These hypotheses are tested in the present study.

METHOD

Subjects

Fifty-four Ss were chosen from classes at Curry School, an elementary school operated by the University of North Carolina at Greensboro. Each child had normal hearing in the frequency range used in the study (as determined by standard audiometric procedures). The ages of Ss were approximately 5, 7, and 9 years with 18 Ss in each age group. Both males and females were used with the general socio-economic status of the children being upper middle-class.

Design

Table 1 illustrates the general procedures administered to each S within each age group.

Apparatus

An autoharp (Oscar-Schmidt) was used in a pretraining session for the 5-year old group in order to establish the concept of "high" and "low" tones.

The apparatus used in testing, training, retesting, and follow-up included two audio oscillators (Model 201C, Hewlett Packard), a decade attenuator (Model 350D, Hewlett Packard), an electronic frequency counter (Model 5221B, Hewlett Packard), three timers (Model 111B, Hunter), three headsets (two TDH-39, one D-1, Grason-Stadler) wired in parallel and mounted in ear cushions (NAF 48490-1, Grason-Stadler) and two impedance matching transformers (Model E10589A, Hewlett Packard). Figure 1 shows

Table 1

Summary Table of Procedures

Age	S-group*	Pretraining	Test	Training	Retest	Follow-up
5	Exp	High-Low	DL	Yes	DL	----
5	Con	High-Low	DL	No	DL	----
7	Exp	----	DL	Yes	DL	DL
7	Con	----	DL	No	DL	DL
9	Exp	----	DL	Yes	DL	----
9	Con	----	DL	No	DL	----

* Exp = Experimental, Con = Control

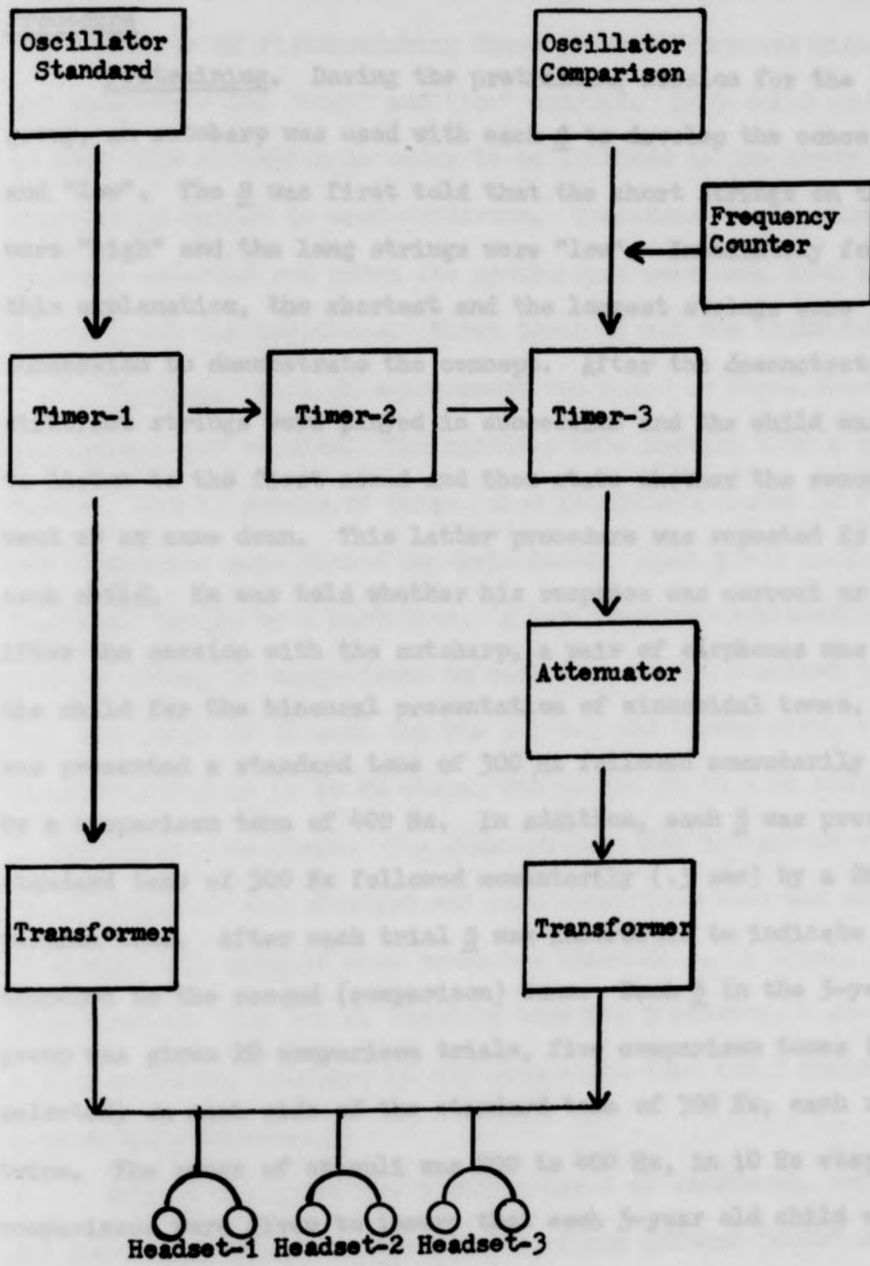

Figure 1. Block diagram of apparatus.

a diagram of the apparatus.

Procedure

Pretraining. During the pretraining session for the 5-year old group, an autoharp was used with each S to develop the concept of "high" and "low". The S was first told that the short strings on the autoharp were "high" and the long strings were "low". Immediately following this explanation, the shortest and the longest strings were played in succession to demonstrate the concept. After the demonstration, two different strings were played in succession and the child was instructed to listen to the first sound and then state whether the second sound went up or came down. This latter procedure was repeated 25 times for each child. He was told whether his response was correct or incorrect. After the session with the autoharp, a pair of earphones was placed on the child for the binaural presentation of sinusoidal tones. Each S was presented a standard tone of 300 Hz followed momentarily (.5 sec) by a comparison tone of 400 Hz. In addition, each S was presented a standard tone of 300 Hz followed momentarily (.5 sec) by a 200 Hz comparison tone. After each trial S was instructed to indicate what happened to the second (comparison) tone. Each S in the 5-year old group was given 20 comparison trials, five comparison tones (randomly selected) on each side of the standard tone of 300 Hz, each repeated twice. The range of stimuli was 200 to 400 Hz, in 10 Hz steps. These comparisons were given to insure that each 5-year old child understood the concept of "high" and "low".

A pilot study had previously shown that the two older age groups (ages 7 and 9) possess the concept of "high" and "low" and thus no pretraining with the autoharp was necessary. The two trials with the earphones, however, were given to all Ss to insure that they could meet the criterion of distinguishing these gross differences without error and understood the "high" and "low" concept. Each child was required to meet this criterion in order to be included in the study. Three 5-year old Ss failed to meet criterion. Therefore, three other Ss were randomly selected and given the pretraining sessions, both with the autoharp and the earphones. These three Ss met the criterion.

Testing. Each DL measurement was based on three sessions, 100 comparisons per session. The children were brought into a quiet experimental room in groups of three (when possible), seated in front of E and headphones were placed on their heads. Each S was isolated from the other two Ss by a partition. A test session consisted of 100 comparison tones, 50 comparisons on each side of the standard tone of 300 Hz. The range of stimuli for the 5-, 7-, and 9-year olds, respectively, was 200 to 400 Hz in 10 Hz steps, 250 to 350 Hz in 5 Hz steps, and 280 to 320 Hz in 2 Hz steps. The standard tone for all groups was 300 Hz. The loudness of the standard and each comparison tone was approximately 77 phons. All stimuli were presented binaurally. A trial, therefore, consisted of: the 300 Hz standard tone for 3 seconds, a one-half second interval, followed by the comparison tone for 3 seconds. Figure 2 shows this sequence.

Each S was given two 5 inch squares of cardboard, one white and the other, blue. On the white card was printed "HIGH" and on the blue card, "LOW". In addition, for the 5-year old Ss, an arrow pointing up or down, respectively, was drawn on each card. Each child was

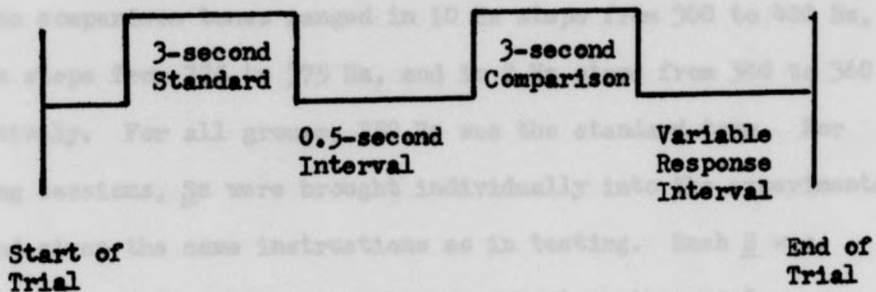

Figure 2. Sequence of a single trial.

instructed to hold up the appropriate card to indicate whether the comparison tone was "higher" (went up) or "lower" (went down) than the standard tone.

Training. After testing sessions were completed, nine Ss were randomly selected (using a table of random numbers) from each age group. These Ss constituted the experimental group and the remaining Ss, the control group. The experimental Ss were given six training sessions, each session consisting of 100 trials with 10 comparison tones presented 10 times each in a random sequence. For the 5-, 7-, and 9-year olds the comparison tones ranged in 10 Hz steps from 300 to 400 Hz, in 5 Hz steps from 325 to 375 Hz, and in 2 Hz steps from 340 to 360 Hz, respectively. For all groups, 350 Hz was the standard tone. For training sessions, Ss were brought individually into the experimental room and given the same instructions as in testing. Each S was verbally told whether his response was correct or incorrect.

Retesting. After the training sessions for the experimental Ss were completed, both the experimental and control Ss had their DL remeasured using the same stimuli as in the original testing sessions. For the 5- and 7-year old groups, approximately 2 months elapsed between the test and retest sessions; for the 9-year old Ss, approximately 1 month elapsed. As in testing, the DL was based on three sessions. At the end of each testing, training, and retesting session, each S in the 5- and 7-year old groups was allowed to select a trinket from a mixture of assorted novelties. All 9-year old Ss earned points each session by doing their very best to give correct responses. They had to earn at least 100 points in order to receive a prize at the end of the study. All Ss earned the required number of points and were given an educational jigsaw puzzle.

Follow-up. Approximately 11 months after the 7-year old group had completed the study, a remeasurement of their DLs was done. Of the original 18 Ss, 14 Ss were still available (two experimental and two control Ss had since moved). The follow-up measurements used the same stimuli and procedures as in the original study. These data were used to examine the effect of training over time and to examine the effect of time on the DL.

RESULTS

The data were collected each day by recording S's response after each stimulus presentation. A DL for each child was computed using the summation method as described by Guilford (1954). The DL was defined as 67 percent of the standard deviation fround by this method. Table 2 shows the DL for each S on test and retest (see Appendix).

An analysis of variance applied to the initial test data yielded a significant result ($p < .001$) indicating that DLs of the groups differed as a function of age. Assuming a fixed effects model, the amount of variance accounted for by the independent variable (w^2) was 42 percent (Hays, 1963). A Scheffe post hoc analysis showed the 5-year old group to be significantly different from both the 7- and 9-year old groups, but the 7- and 9-year old groups did not differ significantly from each other.

An analysis of covariance, with the test session scores as the covariate, indicated that training significantly reduced the DL for the 5-, 7-, and 9-year olds, respectively ($p < .001$, $p < .06$, $p < .01$, Tables 4-6 in Appendix). Assuming a fixed effects model, the amount of variance accounted for by training (w^2) was 57.3, 14.8, and 27.5 percent for 5-, 7-, and 9-year olds, respectively. Based on w^2, training had the most effect on the 5-year old group.

An analysis of covariance, with the test session scores as the covariate, was also applied to the experimental groups to examine the question of differences in DL after training (Table 7 in Appendix). This analysis yielded a non-significant result indicating that no differences in DLs existed among the age groups following training. Although training reduced the DLs of each age group to approximately the same level, an orderly decrease in DLs still existed among the experimental groups, the mean DL for the 5-, 7-, and 9-year olds being 5.8, 3.5, and 2.3 Hz, respectively. The control group for each age level showed no significant change from the test sessions to the retest sessions although a slight decrease in DLs is evident Figure 3).

An analysis of variance on the follow-up data (Table 9 in Appendix) for the 7-year old group (now approximately 8-years old) revealed a significant difference between the experimental and control group ($.05 < p < .10$). Assuming a fixed effects model, the independent variable (training) accounted for approximately 15 percent of the total variability in the data. Thus, the experimental group remained significantly better than the control group almost one year after the training had been completed (Figure 4). Table 3 shows the DL for each S on follow-up (see Appendix).

In summary, the results indicate: (1) DLs, prior to training, were significantly different among the age groups; (2) training significantly reduced the DL for all age groups; (3) DLs, after training, were not significantly different among the age groups; (4) the DLs decreased as a function of time and the experimental Ss remained superior to the control Ss in their ability to discriminate frequencies.

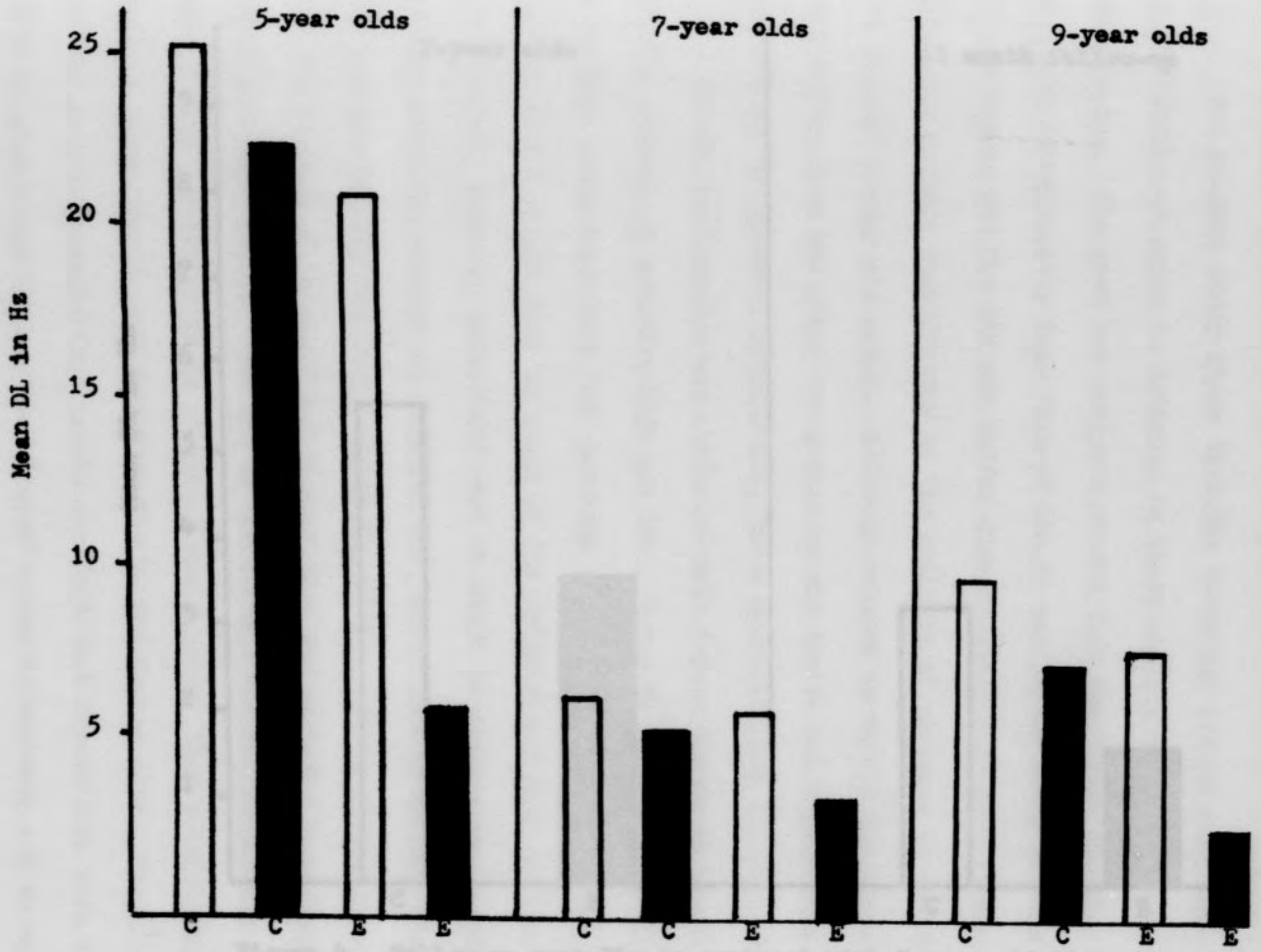

Figure 3. Mean DL values as a function of age. Open bar represents test data; closed bar represents retest data. E = Experimental, C = Control

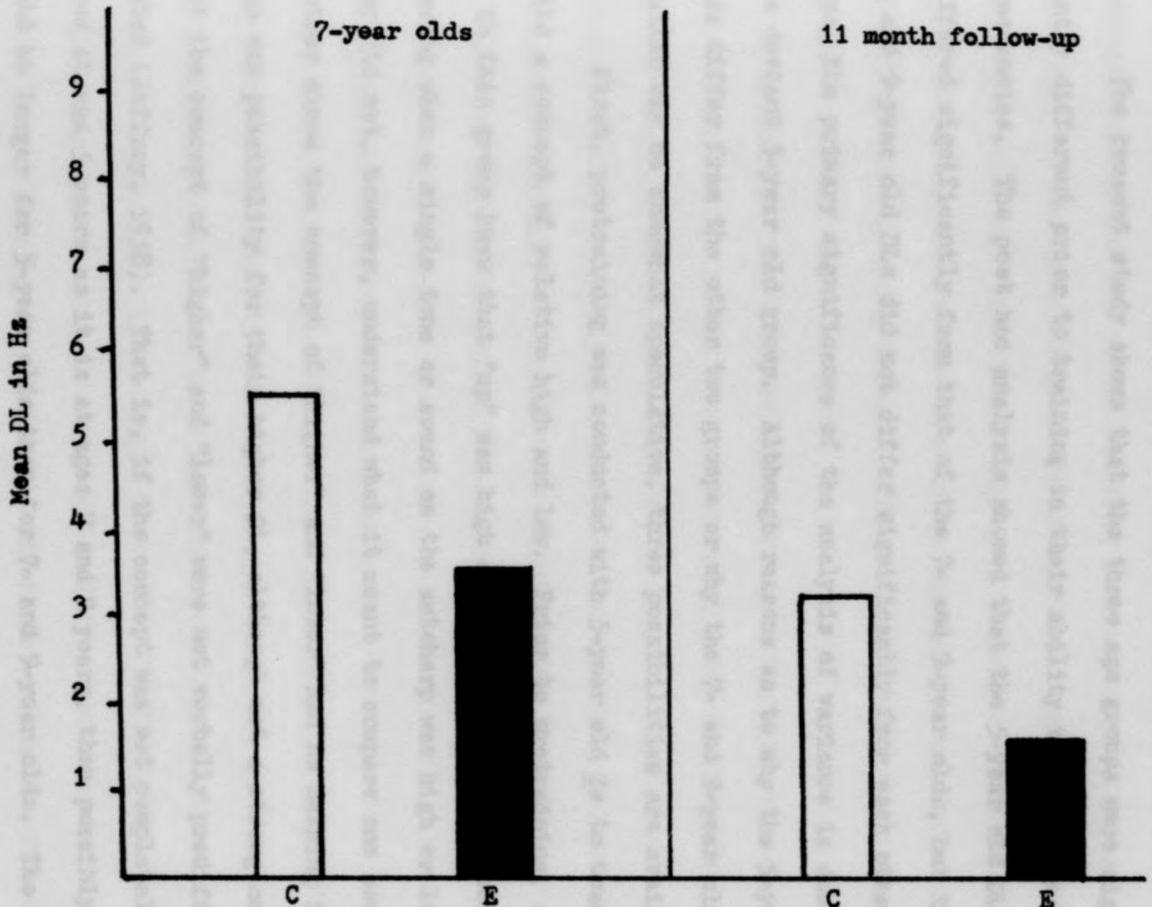

Figure 4. Follow-up mean DLs in contrast with 7-year old DLs. Open bar represents control group; closed bar represents experimental group.

DISCUSSION

The present study shows that the three age groups were significantly different prior to training in their ability to discriminate frequencies. The post hoc analysis showed that the 5-year old DL differed significantly from that of the 7- and 9-year olds, but the 7- and 9-year old DLs did not differ significantly from each other. Thus, the primary significance of the analysis of variance is due to the deviant 5-year old group. Although reasons as to why the 5-year olds differ from the other two groups or why the 7- and 9-year olds are similar may be somewhat speculative, three possibilities are available.

First, pretraining was conducted with 5-year old Ss to teach the child a concept of relative high and low. Prior to pretraining, all 18 Ss in this group knew that "up" was high and "down" was low as well as knowing when a single tone or sound on the autoharp was high or low. They did not, however, understand what it meant to compare one sound to another since the concept of "higher" and "lower" had no meaning for them. Thus one possibility for their higher DL, although not a strong one, is that the concept of "higher" and "lower" were not verbally predifferentiated (Jeffrey, 1958). That is, if the concept was not completely understood at age 5 years as it is at ages 7 and 9 years, then possibly DLs would be larger for 5-year olds than for 7- and 9-year olds. The weakness in this possibility lies in the fact that 5-year olds were required to understand "higher" and "lower" prior to becoming a S in the study. It is possible, however, that the criterion used to determine whether a child understood the "high" and "low" concept was not an accurate guide to determining the level of development of the concept.

A second possibility for the larger DL in 5-year olds is that with increasing age perceptual learning is occurring. A 5-year old has had a limited perceptual experience in auditory stimulation compared to 7- and 9-year olds. With increasing age a child has an increasing opportunity to obtain information from his environment as a result of practice in differentiating among stimuli. The resulting perceptions, therefore, are more specific (Gibson, 1969).

A possible third factor contributing to the differences in DLs with increasing age is the concomitant development of speech skills as a child matures. Recent data reported by Sommers, Meyer, and Furlong (1969) show that frequency discrimination and speech discrimination appear to be related to articulation effectiveness in children. That is, children who have articulation problems also tend to show poor speech and frequency discrimination. Sommers et al. (1969) also found no trend of improvement in frequency discrimination ability as a function of age using third and fourth graders (8- and 9-year olds) or using fifth and sixth graders (10- and 11-year olds) as Ss. Possibly, by the time a child is 7 or 8 years old, he is approaching the maximum in discrimination ability. Support for this is given by Templin (1953) who showed that by age 7 or 8 years the average child has developed adult level articulation skills. These findings may offer one plausible explanation for the non-significant difference found in the present study between the mean test DL for 7-year olds and that of 9-year olds since frequency discrimination and speech discrimination are related.

The results also showed that training significantly reduced the DL for each of the three age groups. But even after training, for the 5-year old group, there was considerable variability among the DLs: the range was from 1.9 to 12.9 Hz (compared with 6.7 to 28.8 Hz on test). This large range is not found in the other two groups after training. The range of DLs within the control group for the 5-year olds remained about the same on both test and retest. Due to the fact that all three age groups had a lowered DL, it would seem that training has a marked effect upon perceptual learning. That is, through additional practice, the child is better able to differentiate among the stimuli.

Although training significantly reduced the DL for all age levels, it had its most significant effect upon the 5-year old group. The DL of all 5-year old Ss was reduced at least by one-half after training. Perhaps, the most salient insight to be gained from these results is that it is possible to train a child at a very early age to discriminate frequencies almost as well as a normal adult is able to discriminate. The adult DL at the standard frequency and intensity (loudness) used in the present study is approximately 2 Hz (Shower and Biddulph, 1931).

Although DLs after training were not significantly different among the age groups, an orderly decrease is evident with age (Figure 3). With continued training, perhaps, the 5-year old DL could be reduced to that of the adult level.

The follow-up data showed that the effect of training is somewhat long-lasting. Experimental Ss maintained their superiority in their ability to discriminate frequencies and, in addition, Ss improved in performance as a function of time. The superiority of the experimental Ss suggests that training improves the ability to perceive differences among stimuli and this learned improvement is permanently retained and reinforced through additional exposure to the environment. The effect of time is revealed in the improvement of control Ss after the 11 months had elapsed. This improvement is indicative that differential learning is occurring as a result of additional exposure to environmental auditory stimuli.

Implications of this research for music educators are of some importance in terms of teaching kindergarten children to better discriminate musical pitch. As suggested by Repina (1961) and by the data presented in the present study, the use of didactic games is helpful in developing concepts which are related to music. Thus, it is suggested that music education for children aged 3 to 5 years may be improved by first demonstrating, through the use of stairsteps and other didactic games, the concept of "high" and "low". Then, through the use of an autoharp or tone bells, high and low sounds may be demonstrated. Once the child understands the concepts underlying musical sounds then through additional practice with comparing sounds, he can be taught the concept of frequency (pitch) differences. Finally, by allowing the child to actually play a sound on the autoharp and then attempt to reproduce it vocally, he should now better understand what he is expected to sing (because he can differentiate the pitches) and thus also be better able to reproduce (sing) the correct sounds.

Another area of interest is the transfer of frequency discrimination ability from one frequency range to another. In the present investigation, the standard was raised from 300 Hz in testing to 350 Hz in training. Since this change is small, the data do not answer the question of transfer. If, however, speech discrimination and frequency discrimination are related as shown by Sommers et al. (1969), transfer from one frequency range to another should occur given the fact that the range of frequencies covered in speech sounds is broad. That is, if it could be shown that by improving frequency discrimination through training in one frequency range an improvement occurred in speech discrimination skills, then it follows that limited training in a narrow range of frequencies may transfer to the broader range of frequencies covered in speech sounds.

Finally, it may also be possible to improve articulation skills through training in frequency discrimination. Van Riper (1954) has suggested that the first step in remedial treatment of articulation problems is systematic ear training. Thus, if an articulatory defective child could be trained to better discriminate frequency, then the ear training involved in this task should aid him in articulating speech sounds.

SUMMARY

The purpose of the present investigation was twofold. First, DLs were measured for 5-, 7-, and 9-year olds and second, the effect of training was noted for each age group. Mean DLs for 5-, 7-, and 9-year olds, respectively, were approximately 23.2, 6.2, and 9.3 Hz. Training significantly reduced the DLs of each age group, respectively, to 5.7, 3.5, and 2.3 Hz.

Four conclusions may be drawn from the present study. First, auditory difference thresholds decrease as a function of age. Second, training significantly reduces DL for 5-, 7-, and 9-year olds. Third, DLs may be reduced to approximately the same level for all three age groups. Fourth, DLs decrease as a function of time and training has a long-lasting effect on maintaining a reduced DL. In addition, suggestions were presented for improvement of music education techniques and for improvement of speech discrimination and articulation skills as frequency discrimination ability is improved.

BIBLIOGRAPHY

Bast, T. H. and Anson, B. J. The temporal bone and the ear. Springfield, Thomas, 1949. Cited by S. J. Hutt, Auditory responsivity in the human neonate. Nature, 1968, 218, 888-890.

Bridger, W. H. Sensory habituation and discrimination in the human neonate. American Journal of Psychiatry, 1961, 117, 991-996.

Duell, O. K. and Anderson, R. C. Pitch discrimination among primary school children. Journal of Educational Psychology, 1967, 58, 315-318.

Gibson, E. J. Principles of perceptual learning and development. New York, Appleton-Century-Crofts, 1969.

Guilford, J. P. Psychometric methods. New York, McGraw-Hill, 1954.

Hays, W. L. Statistics. New York, Holt, Rinehart, and Winston, 1963.

Hirsh, I. J. The measurement of hearing. New York, McGraw-Hill, 1952.

Hutt, S. J. Auditory responsivity in the human neonate. Nature, 1968, 218, 888-890.

Jeffrey, W. E. Variables in early discrimination learning: II. Mode of response and stimulus differences in the discrimination of tonal frequencies. Child Development, 1958, 29, 531-538.

Kasatkin, N. I. and Levikova, A. M. On the development of early conditioned reflexes and differentiation of auditory stimuli in infants. Journal of Experimental Psychology, 1935, 18, 1-19.

Leventhal, A. S. and Lipsitt, L. P. Adaptation, pitch discrimination, and sound localization in the neonate. Child Development, 1964, 35, 759-767.

Pratt, K. C., Nelson, A. K., and Sun, K. M. The behavior of the newborn infant. Ohio State University Press, 1930.

Repina, T. A. O nekotorykh methodoikakh izucheniia zvukovysotoni chuvstvitel'nosti u detei doshkol'nogo vozrasta. Soobshchenie III. Opyt razrabotki methodiki, sposobstvuiushchei formirovaniiu u detei differentsirovannogo zvukovysotnogo razlichiia tembral'no okrashennykh tonov. Doklady Akademii Pedagogicheskikl Nauk RSFSR., 1961, No. 6, 55-60.

BIBLIOGRAPHY

Seashore, C. E. Psychology of music. New York, McGraw-Hill, 1938.

Shower, E. G. and Biddulph, R. Differential pitch sensitivity of the ear. Journal of the Acoustical Society of America, 1931, 3, 275-287.

Sommers, R. K., Meyer, W. J. and Furlong, A. Pitch discrimination and speech sound discrimination in articulatory defective and normal speaking children. Journal of Auditory Research, 1969, 9, 45-50.

Stubbs, E. M. The effect of factors of duration, intensity, and pitch of sound stimuli on the responses of newborn infants. University of Iowa Studies in Child Welfare, 1934, 9, 4.

Templin, M. C. Norms on a screening test of articulation for ages three through eight. Journal of Speech and Hearing Disorders, 1953, 18, 323-331.

Van Riper, C. Speech correction: principles and methods. New Jersey, Prentice-Hall, 1954.

Wolner, M. and Pyle, W. H. An experiment in individual training of pitch-deficient children. Journal of Educational Psychology, 1933, 24, 602-608.

APPENDIX

Table 2

S DLs on Test and Retest

Ss*	5-year olds E	5-year olds C	7-year olds E	7-year olds C	9-year olds E	9-year olds C
S1-T	15.297	25.421	7.631	13.031	6.547	7.208
S1-R	3.114	28.816	7.914	10.772	2.996	3.108
S2-T	27.618	25.015	11.339	9.313	5.171	5.099
S2-R	4.032	28.181	3.634	11.180	2.190	2.188
S3-T	24.906	27.353	7.723	3.836	0	16.026
S3-R	12.935	26.225	4.389	3.636	0	5.679
S4-T	16.308	22.475	4.567	2.740	8.366	19.795
S4-R	2.680	19.942	3.206	3.506	2.406	15.141
S5-T	24.927	24.429	6.100	5.084	6.139	11.937
S5-R	3.600	20.093	2.281	6.367	2.282	11.725
S6-T	6.682	30.409	5.388	4.484	8.802	3.459
S6-R	1.916	28.882	4.315	2.853	3.765	2.404
S7-T	28.645	22.047	7.264	2.044	6.414	16.037
S7-R	10.681	15.362	4.657	0	2.736	14.524
S8-T	16.922	32.266	4.841	10.071	21.973	3.427
S8-R	3.846	27.124	1.141	6.326	3.557	1.641
S9-T	28.732	18.633	.838	6.477	12.218	8.231
S9-R	9.136	7.223	0	4.577	1.137	6.414
Mean-T	21.115	25.339	6.188	6.342	8.403	10.135
Mean-R	5.771	22.428	3.504	5.469	2.341	6.980

*Ss in Test (T) and Retest (R) sessions; E = Experimental, C = Control

Table 3

7-year old DLs and
follow-up DLs

	7-year olds		8-year olds	
Ss*	Experimental	Control	Experimental	Control
1	7.914	10.772	1.580	5.456
2	3.634	11.180	4.206	5.534
3	4.389	3.636	1.221	3.711
4	3.206	3.506	---	---
5	2.281	6.367	---	1.340
6	4.315	2.853	1.641	1.671
7	4.657	0	1.221	0
8	1.141	6.326	0	5.287
9	0	4.577	0	---
Mean	3.504	5.469	1.410	3.286

*Ss not available for follow-up indicated by hyphens (---).

Table 4

Analysis of Covariance
For 5-year level

SV	SS	df	MS	F
treatment	790.736	1	790.736	33.862***
error	350.276	15	23.352	
total	1141.012			

***$p < .001$

Table 5

Analysis of Covariance
For 7-year level

SV	SS	df	MS	F
treatment	15.459	1	15.459	3.952*
error	58.684	15	3.912	
total	74.143			

*$p < .06$

Table 6

Analysis of Covariance
For 9-year level

SV	SS	df	MS	F
treatment	66.104	1	66.104	7.460**
error	132.910	15	8.861	
total	199.014			

**$p < .01$

Table 7

Analysis of Covariance
Experimental Groups

SV	SS	df	MS	F
treatment	14.802	2	7.401	1.414
error	120.389	23	5.234	
total	135.191			

Table 8

Analysis of Variance
Test Sessions

SV	SS	df	MS	F
treatment	2001.847	2	1000.924	21.142***
error	2414.515	51	47.343	
total	4416.362			

***p<.001

Table 9

Analysis of Variance
Follow-up Data

SV	SS	df	MS	F
treatment	12.314	1	12.314	3.430*
error	43.087	12	3.591	
total	55.401			

*$.05 < p < .10$