THE EFFECT OF MULTIPLE DISCRIMINATION TRAINING ON PITCH-MATCHING BEHAVIORS OF UNCERTAIN SINGERS

Susan Yank Porter

This study investigated the effect of multiple discrimination training on vocal pitch-matching and instrumental pitch-matching behaviors, and on the aural music achievement test scores of uncertain singers. Eighty fourth- and fifth-grade students served as the subjects. Multiple discrimination training is a paradigm for concept teaching, during which care is taken to insure that the responses to a concept are controlled by the essential characteristics of the concept rather than by the irrelevant characteristics. The specific multiple discrimination training given to two of the four treatment groups consisted of presenting concept instances in the form of five pitches used as criteria in the pretest while varying the irrelevant characteristics of duration, timbre, and intensity. The procedure for shaping remained constant for all four treatment groups. Each student was reinforced for successive approximations to the correct pitch. Results of this study show that multiple discrimination training, added to successive approximation techniques, is appropriate as a standard part of training for uncertain singers.

Key Words: aural discrimination, concept teaching, elementary education student, instrumental ability, testing, vocal ability.

Pitch discrimination and pitch matching are among the most basic music behaviors to be learned. A substantial amount of research affirms the trainability of these behaviors (Collman, 1972; Fullard, 1968; Klemish, 1968; Lundin, 1967; Norwood, 1972; Powell, 1969; Randolph, 1969; Sellers, 1972; Sheldon, 1964; Smith, 1961). Since pitch discrimination and pitch-matching behaviors are trainable, it is important to ascertain whether incorrect vocal pitch-matching responses result from inadequate vocal control, which may be a function of incomplete maturation, or from an inability to discriminate stimuli accurately. If pitch matching is a problem of inadequate vocal control, then an experiment that assesses both

vocal and instrumental pitch discrimination should either confirm or refute the influence of vocal control. If it is a function of inaccurate stimulus discrimination, however, then applying basic learning theory should be more relevant to the solution of the problem.

Experiments with operant conditioning procedures have shown positive results in the areas of improving vocal pitch accuracy and vocal intonation (Greer, Randall, & Timberlake, 1971; Madsen, Wolfe & Madsen, 1969). Others have studied operant conditioning techniques for their effect on teaching pitch discrimination to students who have been specifically labeled as "uncertain singers" (Campbell & Small, 1963; Cobes, 1969; Cross & Lane, 1962; Jones, 1971; Skinner, 1968). Cobes conducted an experiment to determine the effects of shaping, particularly to discover whether successive approximation or correct response reinforcement alone was the more efficient procedure in helping uncertain singers to sing on pitch. She found successive approximation to be the more effective procedure. Hanser (1974) studied the effect of peer contingencies on instrumental pitch-matching performance and found ten percent of the total variability in pitch-matching performance to be attributable to the number of approvals and disapprovals given by students in a small group activity. As the number of contingent approvals increased, errors decreased; as disapprovals increased, errors increased.

In two other studies investigating the contingencies of reinforcement, in these instances dealing with music discrimination training and music selection behavior, Greer, Dorow, and Hanser (1973) stated: "To date, the data point to teacher approval, specifically the contingent use of high approval, as *the* influential instructional variable (p. 42)." Because there was an observable relationship, although not significant, in music selection behavior between the group learning simple discriminations under high approval and the group exposed to nonmusic activities with the same high approval conditions, it was suggested that further research was needed to investigate specific multiple discrimination training, in addition to teacher approval.

Purpose

The purpose of this research was to determine the effect of multiple discrimination training on aural pitch discrimination, vocal pitch matching, and instrumental pitch matching, as well as any transfer between these variables. The effect of specific behavioral techniques, i.e., operant conditioning and multiple discrimination training, was considered in relation to these dependent variables. Multiple discrimination training, as set forth by Becker, Engelmann, and Thomas (1971), is a paradigm for concept teaching which insures that responses to a concept are controlled by the essential characteristics of that concept (e.g., frequency), rather than irrelevant characteristics (e.g., duration, timbre, intensity).

Method

This study was designed to answer the following questions: (1) Will multiple discrimination procedures increase pitch accuracy more than successive approximation alone? (2) What is the correlation between vocal and instrumental pitch-matching abilities and aural discrimination before and after training? (3) Do uncertain singers perceive differently than they sing, i.e., will there be differences between instrumental and vocal performance? (4) What is the relationship between vocal and instrumental pitch-matching accuracy and time spent and trials to criterion?

To obtain a sample of eighty uncertain singers, 263 fourth- and fifth-grade students were screened on two of the three pretest measures. These students attended a public school in the New York City area and were classified as being of a low socioeconomic status, since approximately sixty-two percent of the families in the district fell below the federal poverty level.

A five-group, pretest-posttest, experimental control design was used in the study. After an initial screening, students were assigned randomly to the following groups:

X_1—multiple discrimination training and vocal pitch matching with successive approximation (MD-VPM)
X_2—multiple discrimination training and instrumental pitch matching with successive approximation (MD-IPM)
X_3—vocal pitch matching with successive approximation only (VPM)
X_4—instrumental pitch-matching with successive approximation only (IPM)
X_5—no treatment

The pretest and posttest consisted of three measures. Pitch Test I of the standardized Music Achievement Test I (MAT) was used to test for aural pitch discrimination ability (Colwell, 1968). A screening procedure used by Cobes (1969) for the identification of uncertain singers was employed as the second measure of the pretest. The screening procedure also served as the pretest for uncertain singers retained after the screening. This vocal pitch-matching task (VPM) was constructed as follows: the student was asked to sing or hum one tone that he or she felt comfortable with. Then the experimenter determined by stroboscope the pitch of the note of the closest scaled tone to the sound emitted. The remainder of this pretest segment was composed of the following five pitches played consecutively on the Johnson Intonation Trainer: the pitch just emitted by the student, a pitch one step above, one two steps above, one a step below, and one two steps below. After each pitch was played, the student was asked to match the pitch vocally. If the student emitted a tone at least one half-step sharp or flat (100 cents deviation), he was credited with one uncertain pitch. Of the five sung, three

uncertain pitches were necessary to meet the operational definition of an uncertain singer.

The third measure of the pretest used an instrumental pitch-matching task (IPM). The student was asked to match the same five stimulus tones as used in the VPM task by moving the variable-pitch control dial on the Intonation Trainer. Dials to be moved were randomly set at one hundred cents above or below the pitch to be matched.

The discrimination training described by Becker, Engelmann, and Thomas (1971) in *Teaching: A Course in Applied Psychology* was used as the major experimental treatment in teaching pitch discrimination. In double discrimination training, as discussed by Becker et al., it is imperative that the response to a concept be controlled only by its essential characteristics. As applied to pitch discrimination, the concept universe becomes individual tones or tonal configurations. A concept instance may be, for example, the tone middle C, and not-instances may be all other tones. Irrelevant psycho-acoustical characteristics that might be varied and/or discriminated as a change in pitch are duration, timbre, and intensity. The specific multiple discrimination training consisted of presenting concept instances (five individual tones) and not-instances while varying the irrelevant characteristics. Since there was a variety of tones (concept instances), as well as irrelevant characteristics, the term multiple discrimination (MD), rather than double discrimination, was considered appropriate.

The VPM task, which followed Cobe's task closely, required the student to listen to the tone presented and, as soon as the tone stopped, to sing the tone he or she had just heard. The tone for each student was the same tone he had originally chosen and had emitted on the vocal section of the pretest (screening procedure). The student was then told that if the experimenter felt he was doing a good job, she would say so. The items for the task consisted of the original response, as specified in the pretest measure. The cent deviation for the criterion tone was plus or minus five cents.

Each uncertain singer in the treatment groups had a possible total of 128 trials available on each of these five pitches in which he was trained. For the multiple discrimination training groups, X_1 and X_2, the timbre, duration, and intensity were varied according to a predetermined plan. The timbres used were flute, clarinet, oboe, and violin. The four decibel levels employed were fifty, sixty, seventy, and eighty. The number of seconds the student could consume during each trial in attaining the correct response was ten, fifteen, twenty, or twenty-five. Initially, sessions were held in which a student could practice beginning the task promptly when a light flashed on and stopping when the light went off. The student was also instructed that he might stop before the light was extinguished if he felt the correct response had been achieved. For treatment groups X_3 and X_4, the timbre was clarinet and the volume was sixty decibels. Students in these two groups were instructed to work until

they felt they had matched correctly, i.e., no time limit was imposed for these trials. The procedure for shaping remained constant across all four treatment groups: each student was reinforced for performances that successfully approximated the correct pitch.

For the instrumental pitch-matching task (IPM), each student was asked to move a designated dial on the Intonation Trainer to make the tone sound the same as the Trainer tone being sounded. The four indicated timbres on the Intonation Trainer were varied in order, as well as in the length and intensity of the stimulus tone, exactly as had been done for the MD-VPM task. Each student was trained in five individual tones. The student received verbal praise for correct or approximation of correct responses, with the experimenter following the same shaping procedures that were used for the VPM task.

Table 1
Correlated Sample *t* Test Results of Significance Between Pretest-Posttest Changes of MAT Scores (0–25)

Group (n = 16)	Pretest Mean	S.D.	Posttest Mean	S.D.	Difference Mean	S.D.	df	*t*
I (MD-VPM)	7.94	2.79	9.19	2.66	−1.25	3.86	15	−1.30
II (MD-IPM)	7.69	3.40	9.69	2.68	−2.00	3.52	15	−2.27*
III (VPM)	9.19	2.26	8.75	2.27	.44	3.14	15	.56
IV (PM)	7.75	2.24	9.06	2.44	−1.31	3.28	15	−1.60
V (Control)	7.81	3.80	9.13	3.07	−1.31	3.38	15	−1.55

*$p < .05$

Results

Pretest and posttest data consisted of scores on a scale of zero to twenty-five for Part I of the MAT, as well as individual vocal pitch-matching (VPM) and instrumental pitch-matching (IPM) scores measured in cent deviation. VPM and IPM scores are error scores, or the amount of cent deviation from the correct pitch. An analysis of variance between pretest scores on each of the three measures, MAT, VPM, and IPM revealed that the means of the five groups were not significantly different. This suggests that the randomization procedures used were successful. A correlated *t*-test was used to assess pretest-posttest changes for MAT scores (see Table 1). Results showed a significant difference in scores for Group II (MD-IPM) beyond the .05 level of significance. No other significant pretest-posttest test results were found with the MAT measure. An examination of the variance for VPM and IPM posttest scores, as shown by the magnitudes of the standard deviations (see Tables 2 and 3), indicated that a correlated sample *t*-test was inappropriate. Upon inspection, however, the treatment effects seem clearly apparent.

An analysis of variance was then run on the MAT posttest scores to test for a difference between treatment means. No significant differences between treatments were found for this variable. Since the data for the IPM and VPM demonstrated an extremely large variation in posttest standard deviations, even the analysis of variance is not robust enough to tolerate such differences. Because inferential statistics are often inappropriate for this type of behavioral design, and since the treatment effects were so clear, it was deemed unnecessary to use statistical tests to delineate treatment effects. Comparison of the most effective treatment effects are facilitated by the use of bar graphs (see Figures 1 and 2). Although there were large differences for the trained variable and the control group, and the trained variable and the untrained variable between VPM posttest means, no large differences were found for MD training versus SA only, trained or untrained on the VPM variable. On IVM there were large differences for the trained variable and the control group. As on the VPM variable, no large differences were found on IPM for MD training versus SA only, trained or untrained.

Following the analysis of VPM, and then IPM, comparisons were made to determine main treatment effects of MD versus SA only. Although no

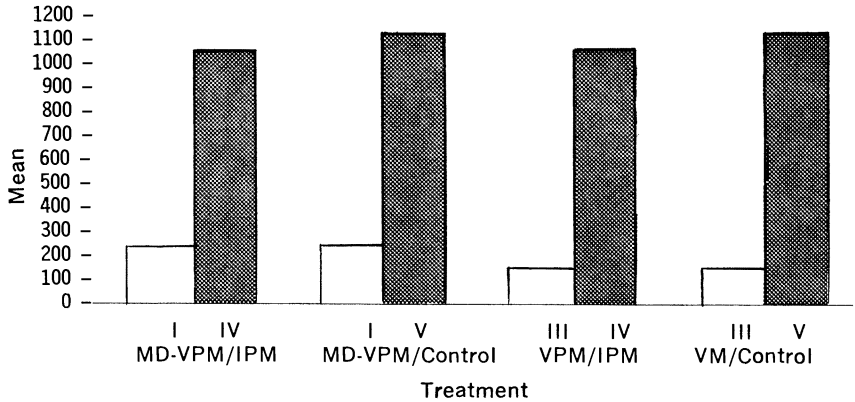
Table 2
Means and Standard Deviations for Pretest-Posttest Changes of VPM Deviation Scores in Cents

Group (n = 16)	Pretest Mean	S.D.	Posttest Mean	S.D.	Difference Mean	S.D.
I (MD-VPM)	1008.56	353.31	218.38	227.96	790.19	360.55
II (MD-IPM)	1234.50	851.10	707.19	525.60	527.31	1172.02
III (VPM)	1158.31	727.34	163.	232.66	955.31	757.98
IV (IPM)	1231.63	652.63	1069.31	795.56	162.31	835.92
V (Control)	1190.19	448.70	1138.81	868.94	217.23	51.38

Table 3
Means and Standard Deviations for Pretest-Posttest Changes of IPM Deviation Scores in Cents

Group (n = 16)	Pretest Mean	S.D.	Posttest Mean	S.D.	Difference Mean	S.D.
I (MD-VPM)	1014.94	288.43	728.13	412.09	286.81	446.40
II (MD-IPM)	1068.50	350.21	23.63	52.36	1044.88	362.75
III (VPM)	996.19	288.26	966.19	195.49	30.00	325.87
IV (IPM)	950.00	291.95	30.56	65.46	919.44	282.14
V (Control)	1162.56	410.51	1125.00	465.49	37.56	431.37

Figure 1. Comparison of Most Effective Treatments for VPM Posttest Scores in Cents



large differences were found when MD training and SA only were compared for VPM and IPM separately, grouping by training procedures regardless of instrumental or vocal training illustrated large differences between MD and SA: untrained multiple discrimination versus untrained successive approximation (see Table 4), and multiple discrimination versus successive approximation, trained and untrained (see Table 5). These differences reveal that MD was more of a factor in increasing pitch accuracy than SA alone. In reference to the untrained MD

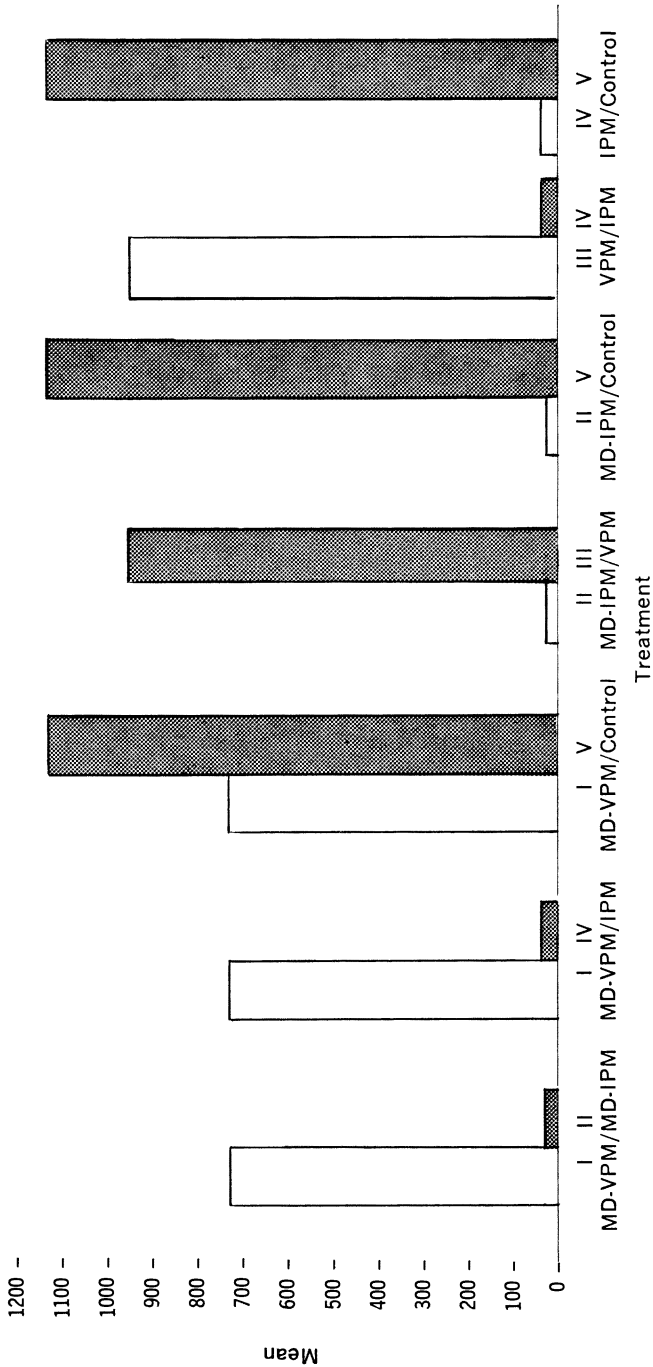
Table 4
Untrained Multiple Discrimination Versus Untrained Successive Approximation

Group Comparisons (n = 32)		Posttest Means	
MD	SA		
I (on IPM)	III (on IPM)	717.66	1017.75
II (on VPM)	IV (on VPM)		

Table 5
Multiple Discrimination Versus Successive Approximation, Trained and Untrained

Group Comparisons (n = 32)		Posttest Means	
MD	SA		
I (on VPM & IPM)	III (on VPM & IPM)	419.33	557.27
II (on VPM & IPM)	IV (on VPM & IPM)		

Figure 2. Comparisons of Most Effective Treatments for IPM Posttest Scores in Cents



versus untrained SA, it is not only important to observe the differences, but also the magnitude of differences between the two means (see Table 4). The means for the trained MD versus trained SA groups were 121 and 96.78, respectively, indicating no difference for this comparison.

Comparisons were made to observe differences between the trained VPM and IPM variables. The means for the untrained VPM and untrained IPM were 888.25 and 847.16, respectively, showing a lack of difference between these variables when compared. VPM versus IPM trained, however, indicated large differences (see Table 6). One of the major questions of this study was whether or not uncertain singers perceive differently than they sing. These results seem to confirm that perception of pitch is not a major problem since students performed better on the instrumental task than the vocal. The magnitude of difference in the means on the tasks is noteworthy and will be considered later.

An analysis of variance used to test the significance of the differences between time spent, in minutes, during treatment for each experimental group showed a significant difference at the .01 level. The use of Scheffé Contrasts indicated significant comparisons ($p < .05$, see Table 7) for five out of the seven groups for time spent during treatment.

An analysis of variance was used to test the significance of the differences between the total number of trials to criterion for each of the four treatment groups. There was a significant difference at the .01 level. Scheffé Contrasts indicated significant comparisons ($p < .05$, see Table 8)

Table 6
VPM Versus IPM Trained

Group Comparisons (n = 32)		Posttest Means	
I (on VPM)	II (on IPM)	190.69	27.10
III (on VPM)	IV (on IPM)		

Table 7
Scheffé Contrasts for Time Spent During Treatment

Comparisons			Significance
Groups (n = 16)	Means		($p < .05$)
I, II	27.94	94.13	sig.
I, III	27.94	19.06	N.S.
I, IV	27.94	52.88	N.S.
II, III	94.13	19.06	sig.
II, IV	94.13	52.88	sig.
III, IV	19.06	52.88	sig.

between three groups for total number of trials to criterion. The Scheffé Contrasts for time spent and trials to criterion during treatment were similarly significant or non-significant for all contrasts with the exception of Groups III and IV. For this contrast, time spent was non-significant, while the total number of trials to criterion was significant. The reason for the differences of time spent and trials to criterion (see Table 9) on VPM and IPM may be explained by the nature of the task.

As indicated in the procedures section, each student was asked to sing or hum one tone that was comfortable. The mean initial pitch for the eighty uncertain singers selected for the experiment was b, whereas the mean initial pitch hummed by 153 students not identified as uncertain singers was c^1. In combining the raw pitch data for the 263 students originally screened, the mean initial pitch was c^1.

Discussion and Conclusions

One observation from this study was that when students were trained on the VPM task, they performed significantly better on VPM than any

Table 8
Scheffé Contrasts for Total Number of Trials to Criterion

Comparisons			Significance
Groups (n = 16)	Means		(p < .05)
I, II	96.94	158.88	sig.
I, III	96.94	93.38	N.S.
I, IV	96.94	68.88	N.S.
II, III	158.88	93.38	sig.
II, IV	158.88	68.88	sig.
III, IV	93.38	68.88	N.S.

Table 9
Means for Number of Trials to Criterion
Individual Pitch and Treatment Group

N = 64	Pitch 1	Pitch 2	Pitch 3	Pitch 4	Pitch 5	Row $\bar{X}$
I	21.06	20.56	21.75	19.75	19.13	20.45
II	68.38	42.31	21.00	18.63	16.00	33.26
III	17.44	23.13	21.19	16.13	16.06	18.79
IV	22.88	12.75	11.50	10.19	10.88	13.64
Column $\bar{X}$	32.44	24.69	18.86	16.17	15.52	21.54

other task, and when students were trained on the IPM task, they were significantly better on that task. This supports considerable previous evidence that one must teach for the specific outcome desired, and not expect automatic transfer of learning to occur without teaching for transfer. Nonetheless, multiple discrimination training did provide evidence for a way of teaching transfer while teaching a specific task. The paradigm of concept teaching as outlined by Becker, Engelmann, and Thomas (1971) is designed to increase transfer of learning. In the present study, students receiving this type of discrimination training performed significantly better on the untrained variables than did those students in the SA-only groups.

While MD procedures did not increase pitch accuracy more than SA alone on trained variables, it was clear that such procedures did increase performance on the untrained variables. One would expect similar accuracy because the performances of all students were shaped to criterion, notwithstanding that the experimental treatment (MD) was geared toward transfer and the other (SA) was not. Several researchers (Cobes, 1969; Greer, Dorow & Hanser, 1973; Hanser, 1974) have found the use of contingent approval to be an extremely important instructional variable when teaching music behaviors. In the present study, all four treatment groups received SA procedures with the contingent use of approval, and all four groups performed significantly better on the trained variables than Group V (Control), which was neither trained in any way, nor exposed to any types of behavioral techniques, i.e., the contingent use of approval.

One of the original questions prompting the design of the present study was whether uncertain singers perceived differently than they sang; in other words, what measurable differences, if any, would there be between instrumental and vocal performance. The IPM cent deviation means were not only significantly different when compared to the VPM means, but also extremely small, thus showing that accurate pitch perception is a behavior that can be rather quickly attained. Since students were able to discriminate the stimulus accurately, as demonstrated by extreme cent deviation reduction on the IPM task, it may be hypothesized that although uncertain singers may not perceive the stimulus accurately before training, they can be taught to do so. That they could not perform as accurately on the VPM task may be the result of inadequate vocal control.

There are other considerations, however, when attempting to answer the above question. Miles (1972) used beat elimination as a means of teaching intonation to beginning wind instrumentalists. The results demonstrated that "no subject was found unable to recognize beats, and every subject was successful at some time on each step that required him to tune unisons free of beats (p. 497)." In the present study, it was observed that some students listened specifically for beats on the IPM task. One student described the sound as not yet rid of the "bumps" when

turning the variable-pitch dial in attempting to match the stimulus tone.

As there were significant differences found on the amount of time spent for the IPM tasks, it may be that the groups trained on IPM were significantly better than VPM groups due to the increased amount of time spent on IPM. When the irrelevant characteristic of duration was varied during the MD training, students soon learned they had to work rapidly in order to match the stimulus tone, particularly during the trial lasting only ten seconds. The ten-second interval occurred every fourth trial. This meant that if the student did not meet the ± 5 cent deviation from the stimulus tone, he or she had to begin again in trying to gain the required ten correct responses in succession to meet criterion on any particular pitch.

This constant rotation of the ten-, fifteen-, twenty-, and twenty-five-second duration of the stimulus tone, and the time allotted to match it, probably accounts for the significant increase of time spent for IPM groups over VPM groups. This also may account for the large number of trials to criterion for Group II (MD-IPM) over any of the other groups. Although Group IV was trained on the IPM task, not as many trials to criterion were consumed by students because no time limit was imposed for matching each stimulus tone.

Training on VPM and IPM, however, did not result in any significant increases on the MAT scores. Moreover, the average gain on the MAT scores for Group V (Control) was competitive with every other group. It might be suggested that the tasks were dissimilar enough that transfer did not occur.

In future research, further applications of this type of training might include tonal configurations and melodies if pitch is to be used as the concept instance. Any one of the irrelevant characteristics of duration, timbre, or intensity might become the concept instance, while making frequency (pitch) an irrelevant characteristic. The same experimental design and subject matter might be used with adults who are still classifiable as uncertain singers, or with very young children.

It should be restated here that pitch discrimination and pitch matching are among the most basic of music behaviors to be learned. The results of the present study show clearly that multiple discrimination training, added to successive approximation techniques, is appropriate as a standard part of training procedures used with uncertain singers. It would be fitting, therefore, to apply such procedures when initially teaching children to sing, rather than waiting until a large population of uncertain singers has developed before introducing remedial programs.

Summary

(1) Students receiving multiple discrimination (MD) training performed better on pitch-matching tasks than did those students in the successive approximation (SA) only groups.

(2) Students receiving MD training performed better on the untrained variables than did those students in the SA-only groups. These results support the hypothesis that MD training not only insures learning a task, but increases the probability of transfer of learning to other related tasks.

(3) Students trained on the instrumental task (IPM) were better at IPM than students trained on vocal pitch matching (VPM) were at their task. Since there were differences found on time spent for the IPM tasks, it may be that the groups trained on IPM were significantly better due to the increased amount of time spent on IPM. Or, it may be hypothesized that students learned to tune unisons free of beats on the IPM task.

(4) There was no evidence demonstrating that faulty singing is the result of inaccurate pitch perception. Superior performance on the instrumental task supports the hypothesis that faulty perception of specific pitches is not the major problem of the uncertain singer.

(5) It appears that training on VPM and IPM had no significant effect in improving MAT scores. On the average the gain on the MAT scores for Group V (Control) was competitive with every other group.

(6) The mean initial pitch response of students qualifying as uncertain singers was slightly lower (b) than that of the more accurate singers (c^1), and pitch behavior was normally distributed.

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Wilmington Public Schools
Wilmington, Delaware