11-19-1976

The Effect of Visual Feedback on Vocal Pitch Matching

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<https://doi.org/10.15760/etd.5927>

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AN ABSTRACT OF THE THESIS OF Anita R. Herron for the Master of Science
in Psychology presented November 19, 1976.

Title: The Effect of Visual Feedback on Vocal Pitch Matching.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Barry Anderson, Chairman

Gerald Guthrie

Robert Powloski

Wilma Sheridan

A review of the literature on the inaccurate singer provided strong evidence that improvement in pitch matching skill was possible. Visual feedback was found to be an effective aid in earlier studies, but none of the previous studies provided both a comparison group which had identical practice without the visual cues and a control group which received no form of practice. Such a design was used in the present study.

Thirty students at Portland State University who claimed to have considerable difficulty carrying a tune were given the opportunity to try to match individual pitches under one of three conditions to which they were randomly assigned. The two experimental groups (I and II) had a period of about 45 minutes to practice matching a prerecorded model of each of the eight notes of the C major scale. There were nine trials per note. Group II received additional feedback from a Strobocoann, which provided visual information on accuracy or degree and direction of error. Group III was the control and had no training period. All subjects' initial pitch matching ability was assessed, and all subjects took a posttest.

The results on pitch matching were not as expected. Analyses of covariance showed that there were no significant effects of practice in general and no significant differences between the two experimental conditions.

The results of self-evaluation, based on interviews given after the posttest, showed that some subjects tended to improve their opinion of their pitch matching ability. This was significant, though only with a one-tailed test ($z = 1.74$, $p < .05$). It thus seems that even a brief opportunity to try out this skill in a relatively non-threatening setting can begin to reverse a lifelong negative self-assessment.

It is speculated that the experiment was too brief to allow the subjects in the Visual group to take full advantage of the Strobocoann. In addition, results of the preliminary assessment measure showed that the tasks may have been too easy for the majority of the subjects, who despite having difficulty carrying a tune, were not severely deficient in their ability to match individual pitches.

THE EFFECT OF VISUAL FEEDBACK
ON VOCAL PITCH MATCHING

by
ANITA R. HERRON

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
PSYCHOLOGY

Portland State University
1976

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ACKNOWLEDGMENTS

Special thanks are due the members of my committee, Barry Anderson, Robert Powloski and Gerald Guthrie, who generously offered their time and provided important guidance in research design and methodology. Their continued encouragement and support were much appreciated.

In addition, I would like to express my gratitude for the time and advice given by other members of the Departments of Psychology, Music, and Speech and Hearing Sciences, and by individuals in the Learning Laboratory and Audio-Visual Services.

Appreciation must also go to all of those friends and students who, despite uncertainty about their voices, volunteered to sing for the pilot studies or the actual experiment.

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CHAPTER I

INTRODUCTION

Music teachers have been striving throughout this century and probably long before to help people learn to sing in tune. Remedial instruction has often been given in an effort to enable the inaccurate singer to participate in music with his peers or to help alleviate the disruption caused by the "monotone, growler, grunter, droner" (Bentley, 1968, p.68). In the literature these people have been called "backward singers," "tonedeaf," "uncertain singers," and "out-of-tune singers" In addition to the four descriptive names cited by Bentley. In the present study, however, the term "inaccurate singer" will be used and defined as follows: someone who consistently is unable to sing at the unison with another voice or instrument of the same pitch range, or, as Joyner (1969, p.115) describes it, one who "consistently fails to reproduce the tonal configuration of a melody in a recognizable manner."

DEFINITION OF THE AREAS

Several aspects of the problem of the inaccurate singer will be examined, including evidence on how the ability to carry a tune develops under normal circumstances and what kinds of factors may characterize the inaccurate singer. Investigators of this problem, in seeking to ascertain just what aspects of musical ability are related to difficulty in carrying a tune, have focussed on pitch discrimination

(PD), pitch reproduction (PR) and tonal memory. They have sought to alleviate the difficulty by emphasizing one or more of these skills in a remedial training program, by which means they hoped to disprove early pronouncements that the condition was not improvable. Being teachers as well as researchers, the investigators have sometimes sacrificed clarity of experimental design in order to provide individualized instruction. The remedial training has usually combined practice with one or more forms of feedback, although in rare cases no external knowledge of results (KR) was provided. Since the present study is concerned with the effect of visual feedback in particular, the literature in this area will be the one most thoroughly reviewed.

CHAPTER II

REVIEW OF THE LITERATURE

I. DEVELOPMENT OF THE ABILITY TO CARRY A TUNE

Some ability to discriminate pitches is present even at birth (Bridger, 1961). Without specific training, between the ages of two and ten the child gradually increases his vocal pitch range (Werner, 1973; Jersild and Bienstock, 1934) and at least up to age 14 is still in the process of developing his ability to carry a tune (Bentley, 1968) and discriminate pitches (Meissner, cited in Werner, 1973, p.101).

A positive relationship has been found between singing ability and the home environment, including such aspects as the fact that the mother sings and/or plays piano, there is music heard, played or appreciated (Reynolds, 1960; Rainbow, 1965; Updegraff, 1938), and there are cultural and socio-economic advantages (Kirkpatrick, 1962).

Some studies have pointed to the negative effect of certain school experiences on singing. A child who has not yet reached the stage developmentally where he can sing accurately may be teased by peers or told not to sing by a teacher, making it more difficult for him to overcome the problem (McNitt, 1971). Boys, who have a much higher incidence of this problem (Bentley, 1968) may feel that singing is for sissies when in grade school (Bentley, 1968) or be embarrassed to sing during the time their voices are changing, and thus withdraw from the very musical experiences that might provide the ear training,

practice in coordination of ear and voice, and flexibility of vocal cords necessary to become accurate singers (Ekstrom, 1959; Swanson, 1959). This has a circular effect later, since the difficulty in singing tends to lead to discouragement and lack of confidence to try to improve (McNitt, 1971).

II. INACCURATE SINGERS: CHARACTERISTICS

Physiological

Individual differences in the physiology of the ear, vocal cords and nervous system do exist, of course, and some of these are likely to affect one's limit of ability. However, there has been little strong evidence to show just how these factors interact in singing, or at what point one can be sure someone has reached that limit, or whether further training of an appropriate kind could still stretch the apparent limit (Farnsworth, 1938). In rare cases an inaccurate singer has a hearing problem like diplacusis (experiencing a single pitch as different in two ears) rather than a deficit in hearing acuity (Culpepper, 1961; Bentley, 1968; Farnsworth, 1938). However, people with diplacusis may also be normal singers (Powell, 1969). Since even so-called "tonedeaf" people usually make and distinguish pitch fluctuations (Abercrombie, 1967) it appears more likely that the problem lies in other areas than the physiology of the ear.

Cognitive

Partly due to the difficulty of assessing physiological and especially neurological differences, many workers have looked most closely at the cognitive aspects of the problem. Relying in part on

introspective reports of subjects and in part on experimental data, they have examined the importance of memory and intelligence in pitch reproduction (PR) and pitch discrimination (PD).

Intelligence. A thorough review of the pre-1968 research by Shuter in The Psychology of Musical Ability (1968), revealed much evidence that IQ is not a significant factor in inaccurate singing or pitch discrimination or tonal memory, except perhaps when the IQ is under 90.

Relationships Among Pitch Discrimination, Pitch Reproduction and Tonal Memory. Much of the early literature deals with improvement in PD rather than PR. Therefore before the remedial training methods are described, the evidence will be examined that PD and PR are related, and that the latter is related to tonal memory as well. Some of the studies show a strong positive correlation, some have non-significant results, but none shows a negative relationship, except for isolated cases (Wing, 1968). Bentley (1968), in reviewing the British literature on "monotones" noted the following studies:

- 1) Fieldhouse in 1937 found a barely significant difference between means on PD tests when comparing 50 young "backward singers" with 96 controls. However, he found a highly significant difference between means on a memory test.

- 2) Fry in 1948, testing 1200 subjects age 11 and up, found a close association between tonal memory as measured by Seashore's 1919 tonal memory test and Fry's own "distorted memory test," on which the subject was to say which of a pair of melodic phrases from familiar tunes had wrong notes in it. Fry defined as tonedeaf those five percent who could not meet the criterion on his distorted melody test,

rather than use any independent measure such as music teachers' rating, as was done by many of the other investigators. Fry did not find a significant correlation between tonedeafness and PD, but it should be kept in mind that he had no measure of his subjects' ability to match pitches vocally.

Bentley (1968) reports results of several broad surveys of 18,000 children ages 7-13 which he did in 1954-1957. On the basis of teachers' identification of monotones, or those who persistently sing out of tune, he found four to four-and-a-half percent were classified as monotones, closely approximating the five percent found by Fry as described above (Bentley, 1968). From the monotones Bentley randomly selected 88 subjects and then selected 312 normal singers of comparable socio-economic and domestic environments, who had had similar classroom music lessons. He found a significant difference between means in tonal memory and PD between normal and monotone singers. These results were also found in two later studies.

Shuter (1968) raises the possibility that these singers have some interference in retrieval of melody rather than a problem of storage. She points to Wilder Penfield's experiments with stimulating the brain during operations for epilepsy. He found that some patients had vivid recall of past musical events and could hum in detail particular pieces that they had heard earlier and heard again as a result of mild electrical stimulation to the brain (Penfield, cited in Shuter, 1968, p.205).

Pedersen and Pedersen (1970) tested two 5th grade classes in two different years, using their own PD test and vocal reproduction test, both of which used tones produced by piano. For group II there was a correlation between the two tests significant beyond the .01 level;

for group 1 the correlation was significant beyond the .05 level.

In 1968 and 1971 Joyner (cited in Roberts and Davies, 1975) tested groups of monotones and a group of normal children at each of five age levels, using pure tones. He found that the pure monotones were significantly worse than normals at PD, but those who could sing tunefully at low pitches were not worse at PD.

In her 1971 study of 100 first graders identified as accurate and inaccurate singers by their classroom teachers and by a vocal test, Zwissler (1971) found the inaccurate had significantly lower scores on PD.

Thus a majority of the research shows a relationship between inaccurate singing and PD. The non-significant results that were reported may have been a function of the tests used rather than of the ability itself, since the tests were often unstandardized instruments designed by the investigators for particular research projects. The literature on remedial instruction, reviewed below, gives some further evidence on the connection, showing that improvement in PR transfers to PD (Cameron, 1917) and the reverse (Capurso, 1934).

Emotional

Although some studies have reported a correlation between inability to carry a tune and maladjustment or low self-esteem (Ramm, 1947; Greenberg, 1970), the evidence seems unreliable since there were no control groups of normal singers tested on the personality measures at the same time.

III. INACCURATE SINGERS: IMPROVABILITY

Issues

The Improvability Controversy. The aim in many of the early studies was to disprove C. E. Seashore's statements (1938, p. 58):

The physiological limit for hearing pitch does not improve with training....Training probably does not modify the capacity of the sense organ any more than the playing of the good violin may improve the quality of its tone.

Seashore had made similar remarks as early as 1910 and his influence in the field of the psychology of music was so important during the first 40 years of this century that his ideas stimulated much research. The above statements were interpreted to mean, for example, that people who did poorly on a Seashore PD test as adults were classed as untrainable. It should be noted, however, that Seashore (1910) did not eliminate the possibility that a test at any time might be tapping the functional, but not the physiological limit, and that the former could increase with training. Indeed, much of this early research did show improvement in PD ability.

The Teacher-Researcher Conflict. In reviewing the literature on the inaccurate or "uncertain" singer, one becomes immediately aware of a conflict between teaching and research: because of individual differences the most effective method for improving PR in one person may be too easy, too difficult, or otherwise inappropriate for another person. In many of the studies, especially the early ones, the investigators chose to emphasize training rather than experimental design, as they adjusted their remedial techniques to fit individual needs. While this seemed to be most helpful to the subjects in any given study, it did not provide clear guidelines for later teachers or

psychologists. Frequently the actual methods of training were glossed over in a report, while the pre- and post-tests, the subjects' introspective comments on what helped them improve, and the degree of improvement were highlighted. Some studies used as subjects those who did worst on the pretest. Others used an unclassified sample and then noted the effect of training on those who performed least well on the pretests.

Some recent workers, more aware of the requirements for good scientific research, have tried, for example, to control subject and treatment variables, carefully quantify independent and dependent variables, and use sophisticated tests of significance. This sometimes leads to statistically non-significant results. However, closer examination of trends within subjects sometimes reveals important leads concerning a treatment whose effects were highly successful for some individuals, but not necessarily overall. Such skewed results suggest the need to investigate further the individual differences that are present in the samples. Thus we are back at the original dilemma: how can one do good research and yet get results which will have wide applicability?

Remedial Training Methods. Although most studies up to now have not reported universal success with any single treatment, many have demonstrated the effectiveness of a large variety of techniques which they used on various samples of singers.

Non-visual Methods

Most of the studies reviewed reported the successful training of inaccurate singers by means of a combination of practice and some kind

of feedback which supplemented the hearing of one's own voice. The feedback included verbal comments on accuracy (Connette, 1941; Knock, 1922; Leontiev, 1957; R. H. Seashore, 1935), observed changes in the larynx (kinesthetic cues) reported by Wyatt (1945), Vernon (1934-35), Mainwaring (1933), Smith (1914) and R. H. Seashore (1935), the simultaneous accompaniment of an accurate model singing or playing the same pitch, and additional sounding of the pitch on one or another instrument or voice between vocal trials (Wyatt, 1945). Practice was also aided in the following ways: imagining the pitch before singing it (Wyatt, 1945) and using earphones to help focus attention and possibly compensate for any partial nerve damage by making use of bone conduction (Leontiev, 1957; Moss, 1973).

Practice alone. In contrast to the studies cited above, two studies were reviewed which reported improvement even though no knowledge of results (KR) was provided the subjects. When Greenberg (1970) placed 10 young inaccurate singers into a grade school chorus at their request, he found that six of them improved considerably although they had been given no special attention. This suggests that their motivation and the opportunity to participate in singing activities without being singled out as different played important roles. Wright (1928) found improvement from practice alone. While practicing the Seashore PD test for one hour daily for five consecutive days, the six adults who had originally scored lowest steadily improved, moving from an average of the 43rd percentile to the 82nd percentile.

Thorndike's work on KR reported in Fundamentals of Learning (1932), suggested that practice without KR is likely to be ineffective, so one might wonder how these subjects in Wright's study improved at

all. It is important to consider the possibility that they received sufficient KR during practice just through their own ears. Evidence for such internal KR was found in 1941 by H. Seashore and A. Bavelas. They looked closely at the data from Thorndike's original line drawing experiment where the subject tried to draw a 4" line with eyes closed, never seeing the results, using 3000 trials, and found that although the subject had not gotten any closer to the 4" line he was supposed to draw, he did come increasingly closer to his own average of 5.01", suggesting to these authors (p.161) that

even erroneous conceptions of what is occurring in his performances constitute part of his KR....Remembered experiences (ideational or motor) and current sensory data, operating on an alert, well-motivated person, are variables which should enable him to learn, even though he has no objective evidence from other persons or by self-measurement with which to check himself.

This kind of internal KR should be kept in mind as a possible source for improvement in the non-visual condition of the present experiment.

Visual Methods

One method which has been shown to be particularly effective in music training is visual feedback, when used as an accessory cue to the auditory experiences of the subject (hearing his own vocal or instrumental pitch). Workers in perception and psychophysics have given considerable attention to the facilitating effect of auxiliary auditory stimuli on visual perception and the reverse (Seif and Howard, 1975; Bernstein, 1970).

Training Instrumentalists. A 1972 study by Guerin looked at the effect of three feedback modes on the intonation of 36 grade school

clarinetists and trumpeters. After four days of training on five of seven pitches for a total of one hour per subject, the group given visual feedback from the Strobocorr (an electronic stroboscopic device which gives immediate indication of which pitch is being sung into its microphone, and whether that pitch is accurate, sharp or flat) in addition to being able to hear their own intonation improved most on the two untrained pitches, which seems strange, but no group improved significantly on the trained pitches. Here one reason group averages may not have reflected change was the presence of vast differences at the start. In addition, training was very brief. Guerin did look at individual performances, however, and found that those who were initially worst improved most regardless of treatment, suggesting that practice with any KR and perhaps the extra attention alone has some positive effect, especially on the poorest group.

Training Singers. In training singers to more accurately match pitches, several visual methods have proved successful. As early as 1910 C. E. Seashore found the tonoscope (a mechanical device that automatically showed the singer the degree and direction of error in a visual representation) to aid in improving the "voluntary control of the pitch of the voice" (p.318). His 6 adult male subjects practiced singing particular tones and intervals 45 minutes daily for 12 days in the following way: five days without visual aid, five days with aid, the 11th day tested without aid, the 12th day tested with visual aid. Although the design was not counterbalanced, the records for the series with aid were on a distinctly different level than for the series without aid, and evidence of gain within each series was not pronounced, so the initial immediate effect of the visual aid was striking.

Heller (1969) used electronic graphs produced by a strip chart recorder to give immediate, continuous visual feedback on pitch matching. His subjects were 12 college music majors. There were two conditions. In both groups the subjects heard the model singing a purposely distorted familiar tune in one ear and heard their own voices in the other ear as they tried to sing along. The second condition provided a visual cue: in addition to the auditory set-up the subjects saw on a moving graph how their versions compared with the model's simultaneously with the subjects' singing it. Half the subjects practiced with the visual cue during the first part of the training, half during the second part, but subsequent statistical tests showed no significant difference due to order. Like C. E. Seashore, Heller found the bimodal feedback superior to auditory alone for frequency matching and pitch adjustment.

Kuhn in 1967 did a pilot study for computer-assisted teaching of sightsinging intervals. In this case the computer indicated whether the sung pitches were correct. Students became more aware of subtle pitch differences and were able to improve their PR, to the criterion established by the program. Although the results were considered tentative and the subjects were music majors, this seems another potentially effective method for giving immediate, mechanized feedback to inaccurate singers as well. The fact that it can be done without any instructor present may be important both for research and training that involve inaccurate singers, who often are embarrassed to sing in front of anyone (McNitt, 1971).

Training Inaccurate Singers. One of the more comprehensive studies prior to the 1960's was that of Wyatt, reported in 1945. After

a thorough critical review of the earlier remedial work, she described her own study in which 16 university students, half of whom were music students, half non-music students (mainly very inaccurate singers), received individual training in PD and PR. After taking the Seashore PD test and Wyatt's own PD test, the subjects were given 12 50-minute training periods in PD and PR, with emphasis on whichever area was weaker. The PR training was only on a few frequencies: the standard 500Hz and the whole and half tones above and below the standard. All subjects had the use of the Strobococon (described above, see Guérin) to check vocal precision and correct their voices if necessary. As is almost always the case in the early research of this nature, the standard training procedure was varied if it didn't produce the intended results. The subjects were first told to listen to the tone sounded 3 times on the oscillator, then to sing into the Strobococon and try to correct their intonation. However, if they still couldn't match the tone, the experimenter tried a series of alternatives:

- 1) used a lower pitch standard, 2) asked the subject to sing along with the standard, 3) played the standard on the piano instead of the oscillator, 4) the experimenter sang the standard. Wyatt notes that the fourth variation seemed to help as a last resort. This would be further support for Knack's idea (1922) that subjects were more easily able to match pitches of a voice in their own range than of a tuning fork, and were even better at matching their own voices.

After training all subjects were retested at least twice, using the pretests as posttests. The scores on the second administration of the pretest were compared with scores on the second posttest. Improvement for music and non-music students was highly significant at the

1% and 2% levels of confidence respectively, on both tests. Wyatt also found significant transfer of PD improvement on two frequencies not practiced. It should be kept in mind though, that these other frequencies were an octave above and below the standard, and the results need not imply transfer to less obviously related frequencies.

Unfortunately no actual testing was done on PR since Wyatt was mainly interested in PD ability. However, the discussion of the training suggests that all the subjects learned to match the few pitches being used. This is another instance in which training in PR was used to augment direct training in PD. However, since no control groups were included who did not have PR training, the effect of its inclusion cannot be measured. In addition, since there was no control group which did not get visual feedback, its effectiveness in isolation cannot be measured.

Despite the evidence of the effectiveness of auxiliary visual feedback, few studies have been done to clearly establish its usefulness in remedial work with inaccurate singers. A study which moved in this direction was done by Wells in 1965. A sample of high school students was assigned to one of three groups: A received 3 minutes of training daily for 20 days, using a Strobococonn; B received the same amount of training, but using the piano; and C participated in normal voice class activity with no extra training. On a posttest of vocal pitch performance, group A made significantly greater gains than B, and both A and B improved significantly more than C. Although only a minority of the subjects had large initial pitch deviations, these seemed to improve more than the others (Wells, 1965), which further supports the hypothesis that something about the visual aid is effective

In training very inaccurate singers.

A much longer and more ambitious training program aimed specifically at the inaccurate singer was carried out by McNitt, reported in 1971. During the course of a summer term, 19 adult "uncertain singers" took between 9 and 16 hours to complete the extensive pre- and post-testing and the self-instructional program designed by McNitt. This is one of the few studies reviewed in which all instructions were taped and training was identical in form for all subjects, although the design of the program allowed the subjects to repeat each part until correct to a criterion. Subjects spent two half-hour sessions weekly until they had completed the program. The training included listening to the tone and imagining it, singing with the model, and singing alone (stages which were adopted for the present experiment) on a series of tasks presumed to be in order of difficulty based on pilot work and previous research. All subjects used the Strobococon for visual KR.

Results on the Seashore PD test and McNitt's own Vocal Pitch and Rhythmic Accuracy test showed no significant relationship between vocal pitch accuracy and either PD or tonal memory, in contrast to Bentley's findings. Thus once more the question is unanswered as to what kind of relationships exist among the components of musical ability. However, McNitt did find a statistically significant improvement in vocal pitch accuracy between the pre- and posttest, and this difference held up on the second posttest, given a week later. McNitt notes that all subjects learned to match the model and all but the two who scored lowest on the pretest were able to sing the test songs without the model after training. As was found in most of the remedial studies, the largest improvement, though not the highest final scores,

occurred in those subjects initially least accurate.

More information concerning just what role visual KR played might have been available if McNitt had used a control group who did not get the visual feedback but used the identical training program.

Summary

Up to this point we have looked at the evidence that PD and PR are related, and that improvement in one usually correlates with improvement in the other even when only one of the two skills is explicitly practiced. In addition, we have noted that many remedial methods have been used with at least some success. However, most of the experimenters were primarily trying to help the singers improve and only secondarily trying to determine precisely what kind and quantity of treatments worked best under what conditions. Therefore the reader or potential teacher is left only with the general sense that individual differences must be considered, but not with clearcut guidelines as to the kinds of treatment that might work best with certain kinds of singers or singing problems.

Indeed, some treatments might be generally effective, at least as a first step, and it is this connection that the present experiment was designed.

Earlier research and the experiences of the author in music teaching and pilot studies have shown that singers are often quite inhibited about singing, having so often been given negative feedback or been told to "just mouth the words" (McNitt, 1971; Wyatt, 1945; Smith, 1914; Whipple, 1903; Bentley, 1968; Ramm, 1947; Greenberg, 1970). In addition they are frequently doubtful that improvement is possible for

them, are hesitant to embark on a lengthy training program that might lead to another failure. For these reasons a treatment was planned which would require no one but the subject to be present during the teaching or training, all of which would be very brief (1½ hours, all at one sitting) and would provide immediate, continuous and unambiguous knowledge of results visually, that is, through a sensory channel not likely to be associated with prior failure at singing.

Previous studies have shown visual feedback to be an effective accessory cue in training psychomotor (Annett, 1959) as well as musical abilities (reviewed above). However, none of the studies of remedial training in pitch reproduction for inaccurate singers that was reviewed provided a design which adequately differentiated between the effect of immediate visual treatment with practice and the effect of the identical practice alone, and then contrasted both of these conditions with a control group which got no practice at all. The present study attempted to do this.

CHAPTER III

EXPECTED RESULTS

This study was designed to investigate whether immediate, continuous visual feedback would be significantly better at helping the inaccurate singer to imitate individual pitches than would the identical training without the auxiliary visual aid. A control group got neither training nor visual feedback so that by comparing all three groups it could be determined whether either experimental treatment had a significant effect.

Based on the literature reviewed and on the pilot studies, it was expected that even a brief training session allowing only nine consecutive trials per note would have the effect of improving an inaccurate singer's ability to correctly imitate the eight single pitches in the C major scale. Thus the two experimental groups should have higher scores than the control group on the posttest. Because of the brevity, however, it was thought that the improvements might not be large or consistent enough to be reflected significantly in the posttest. Therefore a close comparison of the responses during training of the two experimental groups was planned, to provide another measure of the subjects' improvement and to ascertain whether those who received the auxiliary feedback scored higher than those who got no visual cues.

In keeping with the earlier findings and observations made during the pilot studies, it was expected that many of the subjects would have

low voices and thus would experience more difficulty on the higher notes. Low-voiced subjects were expected to have significantly lower scores on the posttest than normal-voiced subjects would have.

The earlier research also suggested that subjects would tend to have normal hearing. No correlation was expected, therefore, between performances on the pitch matching tests and hearing acuity.

Although the major hypotheses were related to the results of the formal experiment, several assumptions were implicit in the research design and comments on these were solicited during the informal interview that followed the posttest. It was assumed that all subjects would appreciate and benefit from having no one in the room, having a vocal model approximately in their own range and having a chance to pace themselves. In addition, it was assumed that the subjects in the two experimental groups would appreciate being able to sing along with the model, repeat each note nine times consecutively and compare their own recorded voices with those of the models. The immediate knowledge of results provided by the visual feedback was expected to reduce the uncertainty about accuracy. Subjects would then be less likely to underestimate their actual ability, be more aware of incremental improvement, and leave with a more positive opinion of their pitch matching ability than they had initially. Also, since the feedback would immediately indicate the direction of error, it was expected to reduce the interference with the task that might otherwise result from the frustration of knowing one was off but not knowing whether to sing higher or lower. Because subjects in the control group were given virtually no time to practice and no indication of accuracy, it was expected that they would leave the experiment least encouraged and

with the least accurate sense of their pitch matching ability.

CHAPTER IV

DESIGN OF THE EXPERIMENT

I. SUBJECTS AND EQUIPMENT

Subjects

Thirty subjects were solicited from classes at Portland State University during the first few weeks of summer session, 1976. In addition, subjects were sought through an advertisement in the Vanguard, the school paper. Subjects were told only that the investigator was interested in volunteers who felt or had been told that they were very uncertain or inaccurate singers, that is, people who had considerable difficulty in carrying a tune or even imitating individual pitches.

Equipment

A Strobocorr, Model 6T-2 was used for providing visual feedback. It gives immediate indication of which pitch is being sung and whether that pitch is accurate, sharp or flat, and to what degree. A photograph of this device appears in Appendix F. A Language Master tape recorder was used for listening to and recording voices during the training sessions and posttest. With it the subjects can repeatedly listen and record, using 4" by 8" cards with strips of recording tape across them. A single pitch was pre-recorded on the left half of each card by a model of the same sex as the subject. An Ampex monophonic tape recorder was used to record both the pretaped stimuli and the subjects' responses

during all tests and training trials.

II. METHODOLOGY

Hearing Tests

Every effort was made to schedule all volunteers for a ten-minute audiological examination, which was administered in the Speech and Hearing Sciences Department by an audiologist. Hearing in each ear was tested at the following frequencies (in Hertz): 250, 500, 1000, 2000, 4000. These fall into the speech frequency range.

Assignment to Groups

At the time of volunteering each subject signed up for a single hour-and-a-half session, at a time convenient for him/her. Each volunteer had the same probability of receiving any one of the three treatments, that is, each was randomly assigned to a group based on the order in which s/he arrived to do the actual experiment.

Initial Assessment of Ability

A measure (referred to as "prescore") was taken at the beginning of each individual session to provide an initial assessment of the subject's ability to match pitches. These results were used as a covariate in some of the subsequent statistical tests to assure that the three treatments had similar proportions of very inaccurate or hardly at all inaccurate singers. This measure consisted of 40 pitches: the eight notes of the C major scale sung five times in random order by a model of the same sex as the subject. Taped instructions told the subject to try to match each pitch vocally. Both the pretaped model's pitches and the subjects' responses were recorded on the Ampex

tape recorder for later scoring.

Instructions for Using Equipment and Doing Procedure. Each subject was given taped instructions describing the equipment and procedure that was relevant for his group. He was also provided with an outline of these instructions typed on cards and a chart for checking off each trial as it was done. Refer to Appendix E for copies of all instructions and charts. All subjects received ten cards for use in the Language Master tape recorder. The first two cards were for practice in the use of the equipment. During this initial five to ten minute familiarization period subjects heard and sang pitches that did not appear on any tests or in the main part of the practice session. The author or her assistant was available if needed to answer questions, but was not present during any testing or practice trials. Each of the main cards had recorded on it one of the eight notes in the C major scale, sung by a model of the same sex as the subject. The pitches were arranged arbitrarily to prevent any improvement as an artifact of the relative ease of singing notes stepwise, as they come in the scale.

Treatment Groups

There were three treatment groups: two experimental groups and one control group. Experimental group I (Non-visual) was given training with auditory feedback; that is, the opportunity to compare their own taped voices with that of the model. Experimental group II (Visual) was given the identical training but with additional visual feedback presented simultaneously. The control group was given no training on the pitches of the C major scale and neither auxiliary auditory nor

visual feedback.

Experimental Session. Each subject in the Visual and Non-visual groups used the following procedure which s/he had become familiar with as s/he learned to use the equipment:

Listen to the model.....Imagine the pitch

Listen.....sing along (2 times)

Listen.....imitate (5 times)

Listen.....record, then listen and compare
recording of own voice with that
of model (2 times)

Each subject in the two experimental groups thus heard and sang each pitch nine times and had two chances to hear her/his own voice on tape and compare it with the model before trying to imitate again. If the subject was in the Visual group (II) then s/he was able to get immediate, continuous visual feedback from the Strobococon throughout the whole session, including the training period and posttest.

Posttest

The posttest included the following steps for each of the eight pitches of the G major scale:

Listen.....Record

Listen.....Record over the first recording

The two experimental groups took the posttest immediately following their nine practice trials on each of the eight notes. The control group took it immediately after becoming familiar with the equipment and being instructed in the posttest procedure. In contrast with the experimental groups, the controls had no practice trials on the pitches

of the C major scale. Thus on the posttest each subject had two trials for imitating each of the eight notes, but the feedback during these trials varied with the group and was comparable to that used during the training session; that is, the Non-visual group got no auxiliary visual feedback, the Visual group got visual feedback and the control group got no visual feedback.

Scoring. All responses on all measures and on the practice trials for the two experimental groups were taped along with the pre-recorded pitches of the models. Two judges, the author and her assistant, used a 5-point scale for the subsequent scoring of each response of the initial assessment measure (prescore), the training procedure and the posttest for each subject in the Visual and Non-visual groups and for scoring the prescore and posttest for those in the Control group. The scale was as follows:

- 0 : more than a whole step off
- 1 : a whole step off
- 2 : a half step off
- 2.5 : a quarter step off or less, but not quite on
- 3 : on pitch

During the scoring it was found that several subjects were approximating the correct pitch except for being an octave above or below the model. This was noted and additional "octave-off" scores kept where relevant. Pearson's correlation coefficients were computed to assess the reliabilities of judgement between scorers, using both the regular and octave-off scores for both judges. The complete scoring plan appears as Table 1 below, in the Results chapter.

Interview

Immediately following the posttest the subjects were interviewed using a semi-structured questionnaire. The suggested questions for the interviewer to use appear in Appendix D. The purpose was to elicit comments on the experimental procedure and the experience, to inquire about the subjects' early musical experiences, how and when they became aware they had trouble carrying a tune and their families' musical abilities and attitudes towards music. Because the interview was not rigorously formal or standardized and because it was suspected that different subjects would tend to elaborate certain areas and respond laconically in others, only limited statistical correlations between the results and the subjects' scores were planned.

CHAPTER V

RESULTS

1. COMPARISON OF GROUPS

Scoring Plan

Each of the two judges used the 5-point scale to score all subjects' taped responses on two measures, a preliminary ability measure (prescore) and a posttest, and to score the two experimental groups (Non-visual and Visual) on the training procedure as well. These three measures (prescore, training procedure and posttest) and the 5-point scale are fully described in the Methods section.

Because it was found that seven of the 30 subjects tended to sing close to the pitch which was an octave above or below the model's, additional octave-off scores were recorded for them, applying the same scale to responses within a whole step of those octave-off pitches. The entire scoring plan, including group means and standard deviations, appears in Table 1 below.

Reliabilities

Pearson correlation coefficients were computed on these variables to assess the level of reliabilities of judgement between the two scorers. Results of this analysis showed that the range of reliabilities was from $r = .98$ to $r = .996$, with an average of $r = .9914$. Because of the high level of reliability, the two judges' scores were averaged and the averages used in all subsequent analyses.

TABLE I
SCORING PLAN WITH GROUP MEANS
AND STANDARD DEVIATIONS

MEASURES	GROUPS	MEANS AND STANDARD DEVIATIONS			
		JUDGE A		JUDGE K	
		Regular	Octave-off	Regular	Octave-off
Preliminary ability measure (prescore): 8 notes of C major scale randomly presented 5 times each	I	$\bar{x}=75.10$ $s=42.69$	$\bar{x}=78.30$ $s=37.58$	$\bar{x}=73.80$ $s=41.72$	$\bar{x}=76.90$ $s=37.38$
	II	$\bar{x}=72.40$ $s=34.99$	$\bar{x}=74.30$ $s=31.82$	$\bar{x}=73.30$ $s=35.84$	$\bar{x}=74.50$ $s=33.82$
	III	$\bar{x}=82.40$ $s=36.61$	$+ +$	$\bar{x}=85.00$ $s=39.31$	$+ +$
Training procedure: 8 notes of C major scale presented in arbitrary order but with 9 consecutive trials per note	I	$\bar{x}=164.60$ $s=68.72$	$\bar{x}=168.10$ $s=64.94$	$\bar{x}=160.80$ $s=68.05$	$\bar{x}=162.90$ $s=65.91$
	II	$\bar{x}=129.80$ $s=73.52$	$\bar{x}=159.00$ $s=46.84$	$\bar{x}=137.90$ $s=60.06$	$\bar{x}=149.10$ $s=58.76$
Posttest: 8 notes of C major scale presented in arbitrary order, but with 2 consecutive trials per note	I	$\bar{x}=38.50$ $s=12.67$	$+ +$	$\bar{x}=37.40$ $s=12.60$	$+ +$
	II	$\bar{x}=34.30$ $s=13.39$	$\bar{x}=38.70$ $s=10.88$	$\bar{x}=34.60$ $s=13.70$	$\bar{x}=37.80$ $s=13.34$
	III	$\bar{x}=36.90$ $s=15.69$	$+ +$	$\bar{x}=35.10$ $s=16.18$	$+ +$

When the octave-off scores were substituted for the regular scores in the seven relevant cases, the changes in the group means were insufficient to warrant doing separate statistical tests. Thus for all other tests only the regular scores averaged between the two Judges were used as the dependent variables or covariate (see Appendix A: Averaged scores on all measures).

Comparisons of Treatments. Despite random assignment to conditions, group averages on the prescore were different, as shown in Table I above. Since fairly high Pearson's correlation coefficients were found between

the prescore and the posttest ($r = .68$ to $r = .97$, with an average of $r = .81$) and between the prescore and the training procedure score ($r = .80$ to $r = .86$ with an average of $r = .83$) analyses of covariance were used to test for the main effect of training and the specific effect of visual feedback during training. Since no way was known to perform an analysis of covariance with repeated measures and because the adjustment for the covariate did not change the results significantly on the preceding two analyses (see Tables II and III below), an analysis of variance was used to compare the subjects' performances on high and low notes.

The purpose of the first analysis of covariance was to equate the three groups statistically according to the prescores and then compare their pretest scores. Despite this adjustment the results showed there were no significant differences among the groups ($F_{2,26} = .865$) (see Table II). This means that the training session had no significant effect, whether or not it included visual feedback.

Results of the second analysis of covariance, comparing the two experimental groups on their adjusted training procedure scores showed that the condition (I:Non-visual, II:Visual) under which the subjects tried to imitate the pitches did not produce significant differences in the overall training procedure scores ($F_{1,17} = 1.587$) (see Table III). The slight trend that did appear was the opposite of that expected: a comparison of the adjusted means showed that the Non-visual group mean of 161.57 was higher than the Visual group mean of 140.83.

TABLE II

NON-VISUAL VS. VISUAL VS. CONTROL CONDITIONS:
COMPARISON OF ANOVA AND ANCOVA
FOR POSTTEST

TEST	SOURCE	SS	DF	MS	F
ANOVA	Condition	SSy Between = 61.517	J-1 = 2	MSy Between = 30.759	F _{2,27}
	Error	SSy Within = 5356.95	N-J = 27	MSy Within = 198.405	= .115 n.s.
ANCOVA	Condition	SSy' Between = 109.056	J-1 = 2	MSy' Between = 54.528	F _{2,26}
	Error	SSy' Within = 1638.172	N-J-1 = 26	MSy' Within = 63.007	= .865 n.s.

TABLE III

NON-VISUAL VS. VISUAL CONDITIONS:
COMPARISON OF ANOVA AND ANCOVA
FOR TRAINING PROCEDURE

TEST	SOURCE	SS	DF	MS	F
ANOVA	Condition	SSy Between = 2493.79	J-1 = 1	MSy Between = 2493.79	F _{1,18}
	Error	SSy Within = 75135.75	N-J = 18	MSy Within = 4174.208	= .597 n.s.
ANCOVA	Condition (adjusted effects)	SSy' Between = 1953.77	J-1 = 1	MSy' Between = 1953.77	F _{1,17}
	Error	SSy' Within = 20919.13	N-J-1 = 17	MSy' Within = 1230.537	= 1.587 n.s. p < .25

11. PHYSIOLOGICAL TRAITS AND PERFORMANCES

Voice Range and Performance

An analysis of variance with repeated measures was performed to compare the two experimental groups on the factor of notes, using as the dependent variable the scores on the training procedure and the posttest for four of the eight notes: the two lowest notes (C,D) comprised the "low" level of the Notes factor; the two highest notes (B,C) comprised the "high" level. The results of this analysis of variance showed that the overall levels of the two experimental groups were not significantly different ($F_{1,18} = .0303$). The subjects' performances were not significantly different on high notes and low notes ($F_{1,18} = 3.8356$, $p < .10$), although there was a trend for performances to be better on the low notes. The mean on low notes, averaged over the two experimental groups was 186.065, while the averaged mean on the high notes was 169.83. However, because the notes of the scale were presented in a fixed arbitrary order, not randomized for each subject, any comparison made between high and low notes is confounded with the variable of position of notes in the series. This should be examined in further studies as a possible source of error.

Low Voices. During the scoring of responses both judges observed that nine of the 30 subjects had especially low voices. A Mann-Whitney U test showed that the scores of those subjects with low voices were significantly lower on the posttest than were the scores of subjects with normal voices ($z = 3.33$, $p < .0005$). An unexpected finding (using the z-test of difference between two proportions) was the non-significant difference between the proportions of low and normal voiced subjects

who did better on low than on high notes ($z = -1.87$, $p < .06$). Low voiced subjects' performances did differ significantly on low and high notes, using a one-tailed test, but contrary to expectations, they tended to do better on high notes ($z = 1.954$, $p < .05$).

Hearing Tests

Audiological examinations were administered to all participants in the study except those four who were unable to make any of the available appointment times due to full-time job commitments. All of the 26 volunteers who were tested showed hearing to be within the normal range, which is ± 10 dB of audiometric 0 for the speech frequencies (in Hertz): 250, 500, 1000, 2000, 4000. The Spearman rank correlation coefficient was computed, using as variables the audiological results for subjects' right ear (which was assumed the more appropriate ear in regard to the digital, or left-brained, nature of the experimental task) and results on the prescores. A very low correlation was found ($r_s = .108$). It is interesting to note that while some of those subjects with the highest scores had exceptionally good hearing, several with the lowest scores in each group also had quite good hearing and several subjects with the worst hearing had moderate to very high scores. Ranks on audiograms and prescores appear in Appendix G.

III. INTERVIEWS

Twenty-eight subjects were interviewed immediately following the posttest. Their responses varied considerably in detail for both solicited and unsolicited information. Because the resulting data were based on varying numbers of responses per question, few quantitative

analyses were attempted and most of the comments and interpretations should therefore be considered suggestive, not conclusive. Throughout the following discussion the proportions of those responding in a particular direction to a given question or volunteering unsolicited information appear in parentheses.

Comments on Design

Subjects considered the following aspects of the experimental methodology to have been helpful:

- 1) Instructions were clear, though complex at times (20 of 25).
- 2) No one was present in the room during any part of testing or practice (17 of 21).
- 3) The visual cueing device gave immediate information on the degree of accuracy or direction of error (9 of 9, Vis. group).
- 4) There was an opportunity to compare one's own voice with that of the model (7 of 9, Non-vis. group).
- 5) There was an opportunity to have many trials on each note and to pace oneself individually (18 of 23).

Some subjects expressed discomfort or annoyance at having to master the complex procedure involving so much manipulation of mechanical devices (5 of 21), but several of these felt nonetheless that the devices had been helpful (3 of the 5).

Opinion of Pitch Matching Ability

An examination of the responses to the questions, "How did you expect to do on this task before you started?", "How do you think you actually did?", and "How did this make you feel?" suggested several trends. Subjects in all three groups tended to improve their opinion

of accuracy regarding their pitch matching ability, apparently just from the process of participating in the experiment, and the proportion was significant, using a one-tailed test ($z = 1.74$, $p < .05$). There was some variation among groups: the Visual group seemed to differ significantly from the controls, using a one-tailed test ($z = 1.82$, $p < .05$), but not from the Non-visual group ($z = 1.28$) (Visual: eight of nine; Non-visual: five of eight; Control: five of ten).

Early Musical Experiences

The early musical experiences reported here parallel those reported in the literature (Reynolds, 1960; Rainbow, 1963; Updegraff, 1938; Shuter, 1968). Subjects tended to find out that they had trouble carrying a tune in grade school (13 of 24) or junior high (8 of 24), usually in a music class or chorus. Often this became a source of embarrassment and frustration, and for some led to social isolation or discomfort, because their immediate family or peers were so regularly involved in singing activities. Many struggled with instruments as children (20 of 28) with varying amounts of encouragement, but very few (2) continued more than three years. Subjects pointed to inadequate teachers, frustration at their slow progress, lack of sufficient encouragement, or the intervention of other more satisfying interests, as explanations for quitting. Despite their lack of success, most of the subjects studied enjoyed music as children (17 of 19) and have continued to do so (20 of 21).

Present Attitudes towards Singing

Somewhat more than a third (9) of those interviewed voluntarily mentioned that they still love to sing and do so alone or with the radio.

A few said they've begun to sing with others. Some continue to feel frustrated or unhappy about not being able to sing easily and well (6 of 8), some have tried to improve (8 of 16), mostly with the help of friends. Others report that they are resigned to their condition and have found other outlets for their musical, creative or vocal needs (2). Although the question was not specifically asked, 8 expressed strong interest in improving their voices, especially if they could have access to a self-instructional method.

CHAPTER VI

DISCUSSION

I. COMPARISON OF GROUPS

Comparisons of Treatments

Results of the formal experiment and of the informal interview suggest that many people who feel they are very inaccurate singers and who indeed may have a great deal of trouble carrying a tune often nonetheless are able to match individual pitches, especially in the lower part of their range. Although this skill may not be improved significantly with only a short-term structured practice session lasting no more than one hour, the experience does have a strong positive impact on the subject's opinion regarding pitch matching ability.

In the present experiment the main results did not come out in the expected direction: statistical tests showed the groups not to be significantly different in performance, as measured by scores on the training procedure and posttest. This may be a reflection of the sample who volunteered or the brevity of the training, which will be discussed below.

Initial Pitch Matching Ability

All volunteers who claimed they had trouble carrying a tune were accepted as subjects and then randomly assigned to groups. The preliminary assessment measure (prescore) was then administered immediately

prior to the start of the training (or posttest, in the case of the Control group). This aspect of the design prevented the author from rejecting as inappropriate those subjects who were able to score very high on the prescore. Although an analysis of covariance was performed on the data to adjust for the subjects' varying abilities at the start, results may have been different if all subjects had had severe difficulty in matching pitches. In the present sample there was a large proportion of subjects (73%) who were already able to match individual pitches with 50% accuracy at the start, and 56% who were able to accurately match over 75% of the 40 random pitches which made up the prescore. In the posttest the task was altered to allow subjects to pace themselves and to have two trials per note, but no substantial practice. The results of this test for the Control group showed that 70% of the so-called inaccurate singers in that group were able to match single pitches with even greater accuracy ($> 91\%$) than they could on the prelim. This suggests that the tasks were too easy or the subjects not as inaccurate as they had assumed, or both.

11. PHYSIOLOGICAL TRAITS AND PERFORMANCES

Low Voices

Although there was only a slight trend ($p < .10$) for performances to be better on low notes than on high ones, this result was noted in the Results chapter because of the literature on the development of children's singing ranges and because of the significantly lower scores on the posttest received by low-voiced subjects in the sample ($z = 3.33$). The literature reviewed suggests the possibility that these low-voiced subjects experienced special difficulty both in grammar school and in

the present experiment because their voices are below the normal range. Farnsworth (1958) and Nye (1962) reported that songs for use in early elementary grades are often written in a range difficult for many children, especially those with low voices. Thus the latter are at a disadvantage from the start, and without appropriate extra help they are likely to feel discouraged and embarrassed. This often leads to withdrawal from the experience and continued vocal difficulty (McNitt, 1971).

It was not unexpected that some of the subjects in this sample would turn out to have low voices. Among the nine who were observed to be straining considerably on the higher notes, five were women who seemed to sing more easily, if not more accurately, in the normal male range and lower part of the female range. Although it would seem likely that the presence of these low-voiced subjects may have been a factor in establishing the slight trend towards better performances on the low notes that was found in the repeated measures of analysis of variance, this was not the case. Despite the strain, low-voiced subjects' performances on the posttest were significantly better on the high notes, with a one-tailed test ($z = 1.954$, $p < .05$). Their overall performances were significantly lower than normal-voiced subjects ($z = 3.33$). This result seems to contradict Joyner's (1969) finding that many so-called "monotones" could sing accurately at lower pitches though they were inaccurate at higher pitches. However, in the present study, the confounding of high and low pitches with position must again be noted as a possible source of error.

Octave-off Responses. Of the seven subjects whose responses gradually approximated the correct pitch (e.g. C, G) but an octave above

or below the model's, five were in the Visual group. Although this proportion did not reach significance on a z-test, the fact that half of the Visual group tended to sing an octave off underscores the need for future investigators who use the Strobocoenn to include instructions on how to discriminate octaves visually. Lacking this information, the Visual group very likely assumed their octave-off responses were correct, because they did cause the discs in the Strobocoenn windows to appear to slow down or stop — the criterion for accuracy.

Hearing Tests

The finding that there was a very low correlation between results of the audiological examinations and accurate pitch matching is in accord with results reported by Culpepper (1961), Bentley (1968) and Farnsworth (1938). They also noted considerable variation in hearing acuity among normal singers as well as among inaccurate singers, as was reviewed in Chapter II above.

III. INTERVIEWS

Comments on Design

Subjects' responses during the interview showed that they appreciated some aspects of the design even if these were not enough to significantly improve their scores. Subjects in the experimental groups considered one or more of the following to have been helpful: self-pacing, privacy, multiple trials per item, clear instructions, and opportunity to compare their voices with the model's. In addition, subjects in the Visual group included as helpful the immediate feedback on accuracy and degree and direction of error.

Opinion of Pitch Matching Ability

One of the design considerations of this experiment was to show inaccurate singers as quickly as possible that they had underestimated their pitch matching ability. It was hoped that their improved opinion regarding this skill would so stimulate and encourage them that they might be able to break the negative cycle of bad early experiences — discouragement, low opinion of singing ability, reluctance to risk trying again. With a more successful experience behind them it was hoped that they would be more willing to invest the time and energy in a longer, more complex vocal training program, should one become available.

It was expected that the Strobocoenn would most effectively and accurately help subjects raise their opinions since it provided them with immediate, continuous information about degree of error. The responses on the informal interview showed that subjects' opinion of their pitch matching ability rose and tended to become more accurate than it had been initially, a result which was significant with a one-tailed test, even though their performances did not improve significantly. However, the Strobocoenn did not have a significantly different effect. Apparently not only the subjects in the Visual group were positively affected by their brief experience. The proportions of those subjects who left the experiment with a better and more accurate opinion of their ability than they had initially were significantly different between the Visual and Control groups (with a one-tailed test), but not significantly different between the two experimental groups.

Although three of the eight who volunteered the information that they would be interested in improving their voices were from the Visual

group, four of the others were in the control group and thus had had no chance to practice. It would seem that the experiment provided an opportunity to check out very quickly one's long-held negative assumptions about a particular musical skill in a relatively non-threatening environment: no one else present, no expectations by others that one should do well or badly.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

Contrary to expectations, at least in the course of this very brief experiment, the visual feedback was not a significant aid. In fact, since subjects had not been taught to discriminate octaves visually and were not necessarily able to do so aurally, several began to approximate the pitch an octave off from the model's, incorrectly interpreting the Strobocoenn.

Although those given visual feedback did not score higher as a group, they tended to comment enthusiastically about the method. Several inquired about the possibility of making individual use of the Strobocoenn after the experiment. The Hawthorne effect cannot be ruled out as a factor here. Indeed, subjects in the Visual group had the most equipment to master and thus the longest instructions and session. However, subjects in all groups tended to improve their opinion about their pitch matching ability, reaching their more accurate assessment apparently simply as a result of participating in the experiment.

In the literature reviewed the Strobocoenn was found to be an effective tool for improving pitch matching of inaccurate singers. It should be noted, however, that none of the previous studies made use of so brief a practice period as did the present experiment. None of those earlier studies compared a group who had received visual feedback with

a group who had had the identical practice without the feedback, so it was never clear whether the training procedure or the fact that visual feedback was given produced the significant effect of treatment. Given the non-significant results of the present experiment, future studies might include a whole series of practice sessions, to try to increase both the overall practice effect and the difference between experimental groups. It would be interesting to see whether the initial slight lead taken by the Non-visual group in this experiment would be maintained or would diminish over time.

The conflict between the need to account for individual differences in subjects and the requirements of solid scientific research remains unresolved. As was noted in the review of the literature, individuals seems to respond best to custom-designed training programs, but these make tight comparisons of effect of different treatments virtually impossible. As a compromise, one might set up carefully designed self-instructional programs which enable each individual to work at his or her own pace and to emphasize those aspects which are most troublesome to that person. As in the present experiment, for comparative purposes one group could be given visual feedback throughout and the other given the identical practice but without the feedback.

II. RECOMMENDATIONS FOR FUTURE RESEARCH

1. A pretest should be given to all volunteers before assigning them to groups to enable the experimenter to analyze the results and divide the subjects into matching groups. Those who score above a pre-established criterion would not be included in the sample. A second administration of the pretest should be given and these scores compared

with posttest scores to minimize error due to regression toward the mean.

2. Those aspects of the design should be kept which seemed to be helpful to the subject for reducing stress, for providing feedback, encouragement and a sense that the task is feasible. These include the following: self-pacing, privacy, multiple trials per item, clear instructions, immediate feedback on accuracy and degree and direction of error, opportunity to compare one's recorded voice with that of the model.

3. As in the present study two experimental groups should be used. Each should be given identical training except for the additional visual feedback which should be provided for only one group.

4. To reduce the potential error due to the Hawthorne effect, attempts should be made to provide the Non-visual group with a different kind of equally novel and complex treatment, either in the form of equipment or attention.

5. Although more complex in design, the training sessions should gradually increase the number of notes in a row to be matched. This would provide a better basis for assessing progress with inaccurate singers and would provide more appropriate training as well. Ideally the models for imitation would eventually approximate actual melodies in length and form. While outside the scope of a master's thesis in psychology, a similar procedure has been attempted with considerable success (McNitt, 1971).

6. At least three practice sessions and preferably several weeks of training should be scheduled. This would accommodate the more complex design proposed in 5. above and be more likely to provide sufficient time for subjects to make significant and, one hopes, long lasting gains.

7. There should be a plan for gradually fading the feedback or "weaning" the subjects who are using visual feedback to the point where they have only auditory feedback. This would help eliminate the problem of overdependence on the visual aid and yet not lose the benefits gained by the initial (or substitutive) visual cueing. The author is aware of no attempt to do this reported in the literature.

8. Subjects who are given visual feedback from the Strobococon should be trained to discriminate among octaves to eliminate that source of error.

9. The taped model should be identical in range to the subject, especially at first. The range could then be extended as the subject gained accuracy within the initial range.

10. A carefully planned questionnaire should be given to all participants, who should be encouraged to respond to every item, thus facilitating quantitative as well as qualitative analyses of the data.

11. Pre- and posttests should be identical to provide an adequate measure of improvement in both experimental and control groups.

12. Careful attention should be paid to the possible effect on performance of order of presentation of stimuli. Appropriate counterbalancing should be included in the design.

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APPENDIX A

AVERAGED SCORES: JUDGE A AND JUDGE K

GROUP	SUBJECT	REGULAR			OCTAVE-OFF (WHERE DIFFERENT)		
		PRESCORE	TRAINING	POSTTEST	PRESCORE	TRAINING	POSTTEST
1	45	83.5	191.5	36	38	115	
	77	107	211.5	47.5			
	82	112.5	207.5	47.5			
	113	56	213.5	47			
	116	111	202.5	47.5			
	149	30.5	87.0	18			
	154	6.5	67.5	24			
	715	103.5	202	47.5			
	1114	112.5	202.5	45			
	1412	21.5	41.5	19.5			
11	16	108.5	131	29	37.5	190.5	43
	23	75	168	43		107.5	40
	24	35.5	101	38.5			
	47	99	198	43.5			
	65	99.5	178.5	42.5		131	42.5
	121	28.5	94.5	26			
	405	67.5	190	42			
	814	13	0	0	5	27.5	4
	1311	97.5	169.5	38.5		182.5	40.5
	1316	104.5	167	42.5			

GROUP	SUBJECT	REGULAR		OCTAVE-OFF (WHERE DIFFERENT)	
		PRESCORE	POSTTEST	PRESCORE	POSTTEST
III	38	108	45.5		
	53	107.5	46.5		
	122	95	45		
	168	6.0	1.5	No differences in Group III	
	169	95	44.5		
	310	27.5	18.5		
	515	117	47		
	613	100	44.5		
	910	111	44		
	1512	70	23		

APPENDIX B

AVERAGED GROUP MEANS AND STANDARD DEVIATIONS JUDGE A AND JUDGE K

MEASURES	GROUPS	MEANS		STANDARD DEVIATIONS	
		REGULAR	OCT.-OFF	REGULAR	OCT.-OFF
<u>Preliminary ability</u> <u>measure (prescore)</u>	I	74.45	77.6	42.04	37.3
	II	72.85	71.1	35.36	31.57
	III	83.88	83.88	37.88	37.88
<u>Training procedure</u>	I	162.7	165.5	68.31	65.37
	II	139.7	142.25	60.55	69.13
<u>Posttest</u>	I	37.95	37.95	12.62	12.62
	II	34.45	38.25	13.53	12.09
	III	36.00	36.00	15.9	15.9

APPENDIX C

ACCURACY SCALES

I. OPINION OF ACCURATE RESPONSES SCALE

(based on interview)

<u>None or almost none</u>	<u>Rare, very few</u>	<u>Some</u>	<u>Many</u>
1	2	3	4

II. ACTUAL ACCURATE RESPONSES SCALE

(based on scores on procedure and posttest)

	<u>Very low</u>	<u>Moderately low</u>	<u>Moderately high</u>	<u>Very high</u>
	1	2	3	4
Procedure:	<u>0-54</u> 1	<u>55-108</u> 2	<u>109-162</u> 3	<u>163-216</u> 4
Posttest:	<u>0-12</u> 1	<u>13-24</u> 2	<u>25-36</u> 3	<u>37-48</u> 4

APPENDIX D

INTERVIEW: SUGGESTED QUESTIONS

COMMENTS ON EXPERIMENT

1. What helped the most? (Not asked Control group)
2. How clear were the instructions?
3. Was it important to have no one in the room?
4. Did you find the preliminary measure (prescore) harder or easier than the rest?
5. In what ways?
6. How did you expect to do on this task before you started?
7. How do you think you actually did?
8. How did this make you feel?

EARLY MUSICAL EXPERIENCES

1. When and how did you learn you have trouble carrying a tune?
2. How did this realization make you feel at the time?
3. How did it make you feel as you were growing up?
4. How do you feel about this difficulty now?
5. What have your musical experiences been? (Choir, Instruments)
6. How long did you continue with it?
7. What kind of feedback did you get?
8. Did you enjoy the experience?

FAMILY AND MUSIC

1. Do your parents carry a tune accurately?
2. Do you remember either of them singing to or with you as you were growing up?
3. Do or did your parents play any instruments? Sing?
4. Can your siblings carry a tune?
5. Do any of them play an instrument, or did they as children?
6. Did your parents encourage you in your early musical experiences?
7. How much music was there at home, on records, radio, live?

ATTITUDES AND INTERESTS

1. What was your attitude toward music as a child? What kinds?
2. What is your attitude now? What kinds?
3. Did you ever try to improve your singing ability? If so, how?

APPENDIX E

TRAINING PROCEDURE AND POSTTEST:
TRANSCRIPTS OF TAPED INSTRUCTIONS,
TYPED INSTRUCTION CARDS,
CHARTS

TAPED INSTRUCTIONS: NON-VISUAL GROUP (1)

You are about to begin a practice session intended to improve your ability to vocally match pitches which you hear. If at any time the instructions are not clear, push the "stop" button on this cassette tape recorder and get the experimenter or her assistant.

In front of you is a special tape recorder called a Language Master and a pile of white cards, each of which has a strip of magnetic tape on the bottom. During the session, you will use one card at a time. The first two cards are for practice in the use of the machine. The remaining cards are for the actual practice part of the experiment. Each card has printed on it a letter representing the pitch which is recorded on the magnetic tape and which you will try to match.

Locate the slot running across the entire top of the Language Master. During the sessions you are to place each card one at a time into the slot, starting at the right and pushing it left until it is caught by the rollers. Then it will move by itself. On the left half of the card, words or a single pitch have been recorded. The right half is blank and at certain points in the procedure, you will be asked to record your response there, that is, the words or the pitch of the model.

Notice the lever on the left side of the front of the Language Master. It is pointing to "listen." In order to record, you must turn it to "record" and hold it there during the entire second half of the card, while you are singing, then release it. When I finish the instructions I will say "try it now" and at that point you may push the "stop" button on this cassette, take the first practice card and

try this procedure until it's comfortable, but please wait until I say "try it now." At that point you will put practice card #1 through once and just listen, put it through again and then imitate the words you just heard, while keeping the lever pointing to record. Please only use practice card one. After you are done put practice card #1 into a different pile from the others, push the "play" button on this cassette and continue with the instructions. The procedure for practice card #1 is also typed on a small index card. You may press "stop" and try it now.

In trying to match the pitches remember to relax your larynx to make a lower sound and tighten it to make a higher sound. Without recording, try now making the highest and lowest tones you can, using the vowel "ee," and notice the difference in tightness in your throat.

You may now use practice card #2 to try the following procedure which you will be using during the actual experiment. Each step requires you to put the card through the Language Master again. After listening to these instructions, take time to read through the procedure which is typed on the large index card, and then try it out for about two minutes, after which the experimenter or her assistant will come in to signal the beginning of the regular practice session.

Here are the instructions:

1. Insert the card, listen and imagine singing the pitch
2. Insert the card, listen, and sing along simultaneously with the model, using the vowel "ee."
3. Listen and sing along again.
4. Listen and imitate the pitch right after the model stops.
- 5-8. Listen and imitate again, four times in the same way,

reinserting the card each time.

9. After you've done the listening and imitating 5 times, reinsert the cards, listen, and right after the model stops, turn the Language Master lever to "record" and hold it there while you imitate the model.

10. Reinsert the card, listen, and then compare your own recorded pitch with that of the model.

11. Again reinsert the card, listen and record.

12. Reinsert the card, listen, compare.

13. Now reinsert the card, listen and record, but do not compare.

14. Reinsert card, listen and record one last time.

Because the procedure is rather complicated, there is a chart for you to use during the whole session. For each card, please put a checkmark in the appropriate box when you have completed that trial. The experimenter or her assistant is available to answer any questions. You may now push "stop" and begin.

Good luck!

TAPED INSTRUCTIONS: VISUAL GROUP (11)

You are about to begin a practice session intended to improve your ability to vocally match pitches which you hear. If at any time the instructions are not clear, push "stop" on this cassette recorder and get the experimenter or her assistant.

In front of you is a special tape recorder called a Language Master and a pile of white cards, each of which has a strip of magnetic tape on the bottom. During the session you will use one card at a time. The first two cards are for practice in the use of the machine. The remaining cards are for the actual practice period of the experiment. Each card has printed on it a letter representing the pitch which is recorded on the strip of tape which you will try to match. The first practice card has some words instead.

Locate the slot running across the entire top of the Language Master. During the session you are to place each card, one at a time into the slot, starting at the right and pushing it left until it is caught by the rollers. Then it will move by itself. On the left half of the card words or a single pitch have been recorded. The right half is blank and at certain points in the procedure you will be asked to record your response there, that is, either the words or the pitch of the model.

Notice the lever on the left side of the front of the Language Master. It is pointing to "listen." In order to record you must turn it to "record" and hold it there during the entire second half of the card, while you are singing, then release it.

After I have finished with the instructions, when I say "try it

now," push the "stop" button on the cassette, take the first practice card and try the following procedure until it is comfortable. Please do not try it yet, but rather, listen until I am finished with the instructions and say "try it now."

Put card #1 through the Language Master slot once and just listen, then put it through again, listen and imitate the words you've just heard and record them while you're imitating them, keeping the lever pointed to "record." Please only use practice card #1 and after you are done with it, put card #1 in a different pile, push the "play" button on this cassette and continue with the instructions. These instructions are also printed on the small index card. You may press "stop" and try it now.

In trying to match the pitches, remember to relax your larynx to make a lower sound and tighten it to make a higher sound. Without recording, try now making the highest and lowest tones you can, using the vowel "ee" and notice the difference in the tightness of your throat.

The machine with windows mounted on a cart in front of you is called a Strobococon, used to give feedback on pitch accuracy. There are twelve windows, one for each note of the chromatic scale. In each window there is a spinning disc, with a series of bands on it. One or more bands on the disc in a particular window will appear to stop spinning when the corresponding pitch is sung or played through the microphone located before you on the desk.

Look now at the first window on the top row, far left, this is C sharp, while I sing C sharp. (Sings C sharp, using "ee.") If I sing too low, or flat, the disc will appear to drift slightly to the left. If I sing too high or sharp, the disc will appear to drift

slightly to the right. Watch while I sing on pitch, then slightly flat with the C sharp. (Does so.) Now watch while I sing on pitch, then slightly sharp with the C sharp. The Strobococonn is intended to give you immediate feedback while you are imitating so you will know if you are singing close to pitch, too sharp, or too flat. Consider your pitch to be sufficiently accurate when the band in the window seems to stop at least briefly, even if it wobbles due to a vibrato or wavering in your voice. Since the machine is very sensitive it will pick up very subtle changes in pitch. Even experienced singers have difficulty getting the band to stay steady. You should just aim at getting the band to slow down and if possible, to stop briefly.

For each card, be sure to check the name of the pitch printed on the card and locate this pitch on the Strobococonn before starting the procedure. When you first seem to be slowing the band down, check the other windows too, to be sure the correct window is the darkest. It does not matter which band of the appropriate disc slows down. Vocal pitch includes overtones; that is, related pitches which will also make the Strobococonn disc stop. But the black lines of the different bands will appear much fainter if you are hitting the overtone instead of the main pitch. Watch the windows for C sharp and G sharp as I sing C sharp, and notice how both stop, but C sharp is darker. (Sings C sharp.) Notice how this changes when I sing G sharp. (Does so.) During the session, once you've established that the band for the pitch you're trying to match is indeed the darkest one that's slowing down when you sing, focus your attention on it during the rest of the steps or trials for that card, and try to make it stop completely. Remember, if the band appears to drift to the left your pitch is flat. Try to alter

your pitch by increasing the tension in your larynx. If the band appears to drift to the right, your pitch is sharp. Try to relax your larynx somewhat, to try to flatten the pitch. If your pitch is closer to another pitch than to the model's, the band in the window corresponding to this other pitch will appear to slow down or stop. If this happens, reinsert the card and continue with the standard procedure, trying to change your pitch.

During the practice, before the regular session you may take some extra time before reinserting the card, to try to alter your voice until it makes a band in the appropriate window stop or slow down. Notice how your voice affects the Strobococonn. During the regular session, try to alter your pitch just during the time the card is going through the Language Master.

Watch now while I sing C sharp, then incorrectly imitate it. (Does so.) Did you see the third window from the left in the top row seem to stop? Watch again, C sharp (sings), imitation (sings F sharp.)

Now take practice card #2. On it is recorded a C sharp. Follow this procedure, which is also printed on the large index card in front of you. Please listen to the whole procedure before trying to do it:

Note: Before inserting each card, check which pitch is printed on it and locate that pitch window on the Strobococonn.

1. Insert the card into the Language Master, listen and imagine singing the pitch.

2. Reinsert the card, listen, but sing along with the model, using the sound "ee" while watching the Strobococonn and try to alter your voice to make the band in the appropriate window slow down or stop.

3. Listen and sing along again.

4. Listen and imitate the model right after the model has stopped, always using the Strobococonn to help you judge your accuracy. Try to alter your pitch so that it makes the band in the appropriate window stop or slow down.

5-8. Listen and imitate again, four more times in the same way, reinserting the card each time.

9. After you have done the listening and imitating 5 times, reinsert the card, listen, and right after the model stops, turn the Language Master lever to "record" and hold it there while you imitate the model, still watching the Strobococonn.

10. Reinsert the card, listen, and then compare your own recorded pitch with that of the model.

11. Again insert the card, listen and record.

12. Reinsert card, listen, compare.

13. Now reinsert the card, listen and record, but do not compare.

14. Reinsert card, listen and record one last time.

That's the entire procedure. Remember to always use the Strobococonn to help you decide whether you are accurate, and the band slows down or stops, or you are too sharp and the band drifts to the right, or too flat and the band drifts to the left.

You may now try practice card #2 with the Strobococonn for about two minutes, after which the experimenter or her assistant will come in to signal the beginning of the regular practice session. If you have any questions at any point, please get the experimenter or her assistant. Because the procedure is rather complicated, there is a

chart for you to use during the whole session. For each card, please put a checkmark in the appropriate box when you have completed that trial. You may now push "stop" and begin.

Good Luck!

TAPED INSTRUCTIONS: CONTROL GROUP (III)

You are about to begin an experimental session on vocal pitch matching. If at any time the instructions are not clear, push "stop" on the cassette tape recorder and get the experimenter or her assistant.

In front of you is a special tape recorder called a Language Master and a pile of white cards, each of which has a strip of magnetic tape on the bottom. During the session you will use one card at a time. The first two cards are for practice in the use of the machine. The remaining cards are for the actual experiment. Each card has printed on it a letter representing the pitch which is recorded on the strip of tape and which you will try to match.

Locate the slot running across the entire top of the Language Master. During the session you are to place each card into the slot starting at the right and push it to the left until it is caught by the rollers. Then it will move by itself. On the left half of the cards, words or a single pitch have been recorded. The right half is blank and at certain points in the procedure you will be asked to record your response there, that is, either the words or the pitch of the model.

Notice the lever on the left side of the front of the Language Master. It is pointing to "listen." In order to record, you must turn it to "record" and hold it there during the entire second half

of the card while you are singing or speaking, then release it.

When I have finished the instructions and say "try it now" you are to push the "stop" button on this cassette, take the first practice card and try the procedure, but please wait until I say "try it now." This procedure is printed on a small index card as well, in case you forget.

The first thing to do is to put the card through once and just listen to it. Then put it through again and imitate the words you just heard while keeping the lever pointed to "record." Please only use practice card 1. You may do it two or three times if you need to, to become comfortable with the procedure. After you are done, place practice card one in a different pile and push the "play" button on this cassette recorder to continue with the instructions. You may press "stop" and try it now.

In trying to match the pitches, remember to relax your larynx to make a lower sound and tighten it to make a higher sound. Without recording, try now making the highest and lowest tones you can, using the vowel "ee" and notice the difference in tightness in your throat.

I will now tell you the procedure you will be using for practice card 2 and the rest of the experimental cards. If you have any questions, the experimenter or her assistant will continue to be available to answer them. After you feel comfortable with the procedure let the experimenter know and she or her assistant will start the tape recorder for the experimental session itself. The procedure for all the rest of the cards is printed on another small index card and I will let you know what it is now:

Insert the card, push it until it is caught by the rollers,

listen to the model on the first half of the card, and immediately turn the lever to "record" and hold it there while you imitate the model, for the entire second half of the card. Reinsert the card and try the procedure again, listening to the first half and immediately imitating on the second half of the card, while holding the lever on "record." After you have done this the second time, go to the next card. In each case you are to listen and record two times for each card. When you have completed all the cards, please let the experimenter know that you are finished. You may now press "stop" and try the procedure with practice card 2 until you are comfortable with it, then signal the experimenter that you are ready to begin on the regular cards. Press "stop" now.

Good luck!

TYPED INSTRUCTIONS

PROCEDURE FOR PRACTICE CARD 1 (ALL GROUPS)

1. Insert card in slot from rt. to left. Push until it catches. Let it go through and listen.
2. Reinsert, listen, imitate the words you just heard, while the lever pointed to "record" only during the second half of the card.
3. You may repeat this procedure a few times if needed, until you are comfortable with it. The experimenter is available to answer questions.
4. Push "play" on the cassette to continue with instructions.

PROCEDURE FOR PRACTICE CARD 2
AND ALL CARDS DURING THE REGULAR SESSION
GROUPS 1 (NON-VISUAL) AND 2 (VISUAL)

1. Insert card listen imagine singing the pitch
2. " " " sing along simultaneously with model,
 using vowel "ee"
3. " " " sing along again
4. " " " Imitate pitch right after model stops
5. " " " " " " " " "
6. " " " " " " " " "
7. " " " " " " " " "
8. " " " " " " " " "
9. " " " record your imitation, holding lever
 on "record" and singing right after
 model stops
10. " " " compare recorded pitch with model's
11. " " " record your imitation using same card,
 thus recording over your first
 recording
12. " " " compare
13. " " " record without comparing
14. " " " " " "

CHART: GROUPS I AND II

	D	A	C	F	B	E	C	G
Listen-Imagine								
Listen-Sing along								
Listen-Sing along								
Listen-Imitate								
Listen-Imitate								
Listen-Imitate								
Listen-Imitate								
Listen-Imitate								
Listen-Record								
Listen-Compare								
Listen-Record								
Listen-Compare								
Listen-Record								
Listen- Record								

CHART : GROUP III

	D	A	C	F	B	E	C	G
Listen-Record								
Listen-Record								

APPENDIX F

Figure 1—The Complete Shadocan, Model 87-2

1. Microphone
2. Scanning Unit
3. Transposing Knob
4. Motor Switch
5. Power Switch
6. Air Power Cable

7. A-4 Connection
8. Interconnection Cable
9. Tuning Unit Scale (Sharp Side)
10. Tuning Unit
11. Scanning Windows

12. Key Signature Window
13. Microphone Connection
14. Volume Control
15. Tuning Scale (Flat Side)
16. Tuning Unit Scale Pointer
17. Tuning Knob

APPENDIX G

RANKS ON AUDIOGRAMS AND PRESCORES

Subject	Rank* on audiogram	Rank* on prescore
77	3	8
82	11	2.5
113	7.5	18
149	15	20
154	22.5	25
1114	26	2.5
1412	13	23
16	11	5
24	15	19
47	1	12
65	24.5	11
121	3	21
405	5	17
814	15	24
1311	20.5	13
1316	24.5	9
38	17.5	6
53	7.5	7
122	17.5	14.5
168	3	26
169	7.5	14.5
310	20.5	22
515	7	1
613	22.5	10
910	19	4
1512	11	16

* A rank of 1 was given to the highest score and to the most acute hearing.