Developing Choral Sound Through Rehearsal Techniques Based On Cybernetic Principles

By Allen Goodwin

What can you do to make the sound of your choir more beautiful? Some answers to this question may be found by attending workshops and clinics or by watching successful directors ply their craft in rehearsals. Sometimes, however, answers come from what appear to be unusual sources — even sources outside the choral field.

Decades of research have produced a mass of data concerning how the human brain processes sensory information and coordinates speaking and hearing. This research has been applied to a wide variety of uses, such as improving electronic communication equipment, extending the capabilities of electronic computers, and producing more "human-like" robots for industrial use. While conducting a research project concerning individual voices and the phenomenon of choral blend, this writer found that many of the concepts widely applied in the field of speech and hearing science appear to explain why certain rehearsal procedures are effective for developing choral sound and others are not.

The first part of this article explains cybernetic principles which have been indicated by research, how those principles have been successfully applied in speech therapy, and how they may be useful for devising effective choral rehearsal techniques. The second part of this article suggests practical rehearsal ideas for developing choral sound. These techniques, based on cybernetic principles, are systematic procedures borrowed from approaches which are widely used in speech therapy.

Cybernetic Principles

The term **cybernetics** (from the Greek **kubernètès** = steersman) was adapted by Norbert Wiener in 1948 in connection with his study of communication and control in the theory of messages (8). A servomechanism, as the concept prevails in the field of engineering, is a device that automatically operates and controls various kinds of machines (5, p. 5). These devices are goal-directed, error detecting, error measuring, automatically self-adjusting mechanisms that control a machine by feeding information back into it concerning the machine's performance. In this way appropriate corrections are made whenever performance errors are detected (5, pp. 6-7).

What do thermostats, guided missiles, and singers have in common? Posed by the writer to students in vocal pedagogy classes, this question almost always produces puzzled expressions. The answer is that all three function as servomechanisms. They all have performance goals and the capability to detect errors in relation to those goals. As information is fed back concerning their performance, they automatically adjust themselves by making corrections appropriate for their goals.

A thermostat, set to a certain level, continuously monitors the temperature and turns on heating or cooling units appropriately whenever deviations from the temperature goal are detected. Similarly, a guided missile, locked on its target, continuously senses changes in its own position relative to the target, and automatically changes the thrusts of its engines to keep itself aimed toward the target. So also a singer, having a "target sound," monitors the sound output with the ear. Differences detected between the intended sound and the perceived sound cause the singer automatically to bring the sound "on target" by adjusting the positions of dozens of muscles controlling breath pressure, the length and tension of the vocal folds, and the positions of the mouth, lips, and tongue.

At first the concept of a singer functioning as a servomechanism may appear remote to the everyday problems of rehearsing a choir, however, there is more to understand about the process before such applications can be made. Many of the processes in the human body can be explained as servomechanism functions. These include the processes that cause the body to maintain a constancy of temperature, water, sugar, calcium, oxygen, and other necessities (4; 5, p. 7). Fairbanks (2) has incorporated servomechanism functions into an operational theory of the speech mechanism. Mysak (5) has applied the concept of servomechanisms to a theory of speech therapy. The principle has been extended in practical applications to articulation therapy in both the clinic (6) and the classroom (7).

The essence of the servomechanism concept of speech production is that the feedback of sensory information enables a person to control and adjust his speech. There are three basic aspects of this feedback: inspection, comparison, and correction. Inspection involves receiving information from the speaker's senses. As a person talks, he hears himself (aural sensations). He feels the tongue against the roof of the mouth and the lips touching the teeth (tactile sensations). He senses the location and degree of muscle tension and joint movement (kinesthetic sensations).

It is believed that, for a given vocal utterance, the brain stores the aural sensations associated with the acoustical features of the sound along with the tactile and kinesthetic sensations associated with the vocal production of the sound. Thus, a given sound is identified with specific aural, tactile, and kinesthetic sensations associated with the sound and stored in the speaker's memory (6, p. 111).

Comparison involves comparing each aspect of the speech output point-to-point with the "sound" stored in the brain's auditory memory in order to discover the nature and extent of error with the intended sound (3, p. 29).

Correction involves relaying corrective data to the motor area of the brain, which is the origin of the nerve impulses to the muscles controlling the speech output. Precorrection is a phase of the correction stage in which the speaker conceives, or "prehears," the word he is about to speak, inspects the set of muscles about to be employed in producing the word, and makes required corrections in muscular control as the word is spoken (3, p. 29).

This entire process operates with phenomenal speed, and occurs in the form of a loop. Part of the output (sound) is fed back into the organism, where it is compared with the goal (the intended sound). A resulting error signal is then sent to the motor control center of the brain, which sends nerve impulses to effect appropriate changes in the muscles controlling the sound output.

When the process is first being learned, by a child, for example, each stage in the loop has to be consciously controlled. But as a goal is reached successfully (the articulators so controlled that the utterance is correct) and reinforced (by approval actions of a parent), the process becomes automatic (3, p. 30).

By implication, failure to utter a sound correctly is chargeable to one or more facets of the process. Wrong information may be stored in the memory. In the case of aural sensations, this could result from defective hearing, for example. In the case of tactile and kinesthetic sensations, it could result from reinforcement of incorrect articulatory positions (approving the utterance "tandy" rather than "candy," for example).

Even with correct information stored in the memory, the process may be disrupted if the feedback links function poorly. For example, a shot of novocaine at the dentist's office may result in temporary interruption of the normal tactile and kinesthetic sensations of speech, even though the aural feedback is often sufficient to maintain intelligibility. Similarly, an individual listening to music on earphones and trying simultaneously to carry on a conversation may make his voice louder than normal in order to offset his reduced ability to hear himself.

Articulation therapy, based on the servomechanism concept, involves identifying the stage or stages in the speech process where a given articulation problem originates and reopening the feedback loop to conscious control by using therapeutic techniques. The client can then recognize the cause of the articulation problem and concentrate on learning a new mode of approach. With guidance from the therapist and through practice, the new approach then can become a natural and automatic part of the client's speech habits (3, pp. 30-33; 6, pp. 119-163).

The physiological similarities between speech and singing permit the procedures of speech therapy to be adapted for use in choral rehearsals. Choral rehearsal techniques based on the servomechanism concept first involve identifying the stage or stages where a problem of choral sound is likely to originate. Next the director helps the individual singer recognize the cause of the problem and concentrate on learning a new approach. Through practice and guidance from the director, the new process of producing sound then becomes natural and automatic for the singer.

A cybernetic model of the individual singer's task in achieving a blend with an ensemble is represented schematically in Figure 1. This schematic representation was adapted from similar diagrams by Fisher (3, p. 28) and by Denes and Pinson (1, p. 5), illustrating analogous tasks in speech. The processes described in each of the five steps to follow are based in similar processes suggested by Fisher (3, pp. 25-33), Van Riper and Irwin (6, pp. 105-111), Mysak (5, pp. 17-33), and West (7, pp. 51-60) for operation of the speech mechanism. Technically, each of the stages might be further broken down into smaller steps. However, for purposes of clarity and simplicity, the stages described seem sufficient.

First, the singer conceives the sound about to be produced. He has a mental image of the aural sensations associated with the sound and the tactile and kinesthetic sensations associated with producing the sound. He literally hears the sound in his mind and imagines the accompanying muscular movements.

Second, the singer produces the sound. By an action of his will, the motor control center of the brain sends nerve impulses which induce action by the muscles controlling breath pressure, phonation, resonation, and articulation.

Third, the singer attempting to blend hears himself and the rest of the singers in the ensemble. The acoustic signals are transformed into neural impulses and sent to the auditory cortex portion of the brain, where they are registered as sensations of sound.

Fourth, the singer perceives details in the sound. The brain scans the sound for recognizable details, identified as pitch, vibrato characteristics, loudness, vowel quality, and timbre. These are compared against a file of such sensations stored in the auditory association area of the brain. The singer's ability to discriminate acoustical details is dependent on his having stored in his memory a corresponding aural reference with an attached meaning. For example, the aural sensation associated with the concept of flatness or sharpness has as a stored reference similar sensations of tones being misaligned with respect to one another. These stored sensations represent sensory experiences which the singer at some time in the past learned to associate with the appropriate concept.

Fifth, the singer evaluates the blend of his own voice with the ensemble. The incoming aural sensations are compared point-by-point with a reference — a set of aural sensations stored in the auditory memory and associated with the concept of vocal blend. The extent of detail for which comparisons are possible is dependent on the extent to which certain aural details are stored with an attached meaning in the singer's auditory memory, as described in the preceding step. If differences are noted, an altered sound is conceived. The aural, tactile, and kinesthetic sensations associated with the new sound are preinspected as the motor control area of the brain sends appropriate neural impulses to affect the required muscular movements of the vocal mechanism.

This process results in a loop, producing continuous acoustical alterations of the sound output until stability is maintained. That is, either the intended goal is reached or another, perhaps arbitrary, goal is substituted.

The actions are those of a servomechanism: a goal-seeking, error detecting, error measuring, automatically self-adjusting unit. Failure to achieve a goal (vocal blend) is thus chargeable to one or more of the stages in the process. As in the analogous situation of speech therapy, a given singer's difficulty in blending may be identified by assessing the singer's success at each step. Remedial or training activities are then suggested by implication. In this manner, development of a vocal blend may proceed in a logical manner by using techniques aimed at achieving specific, identifiable goals. Logically, any other choral objective similarly related to vocal blend — choral tone and balance, for example — may be approached in a similar way.

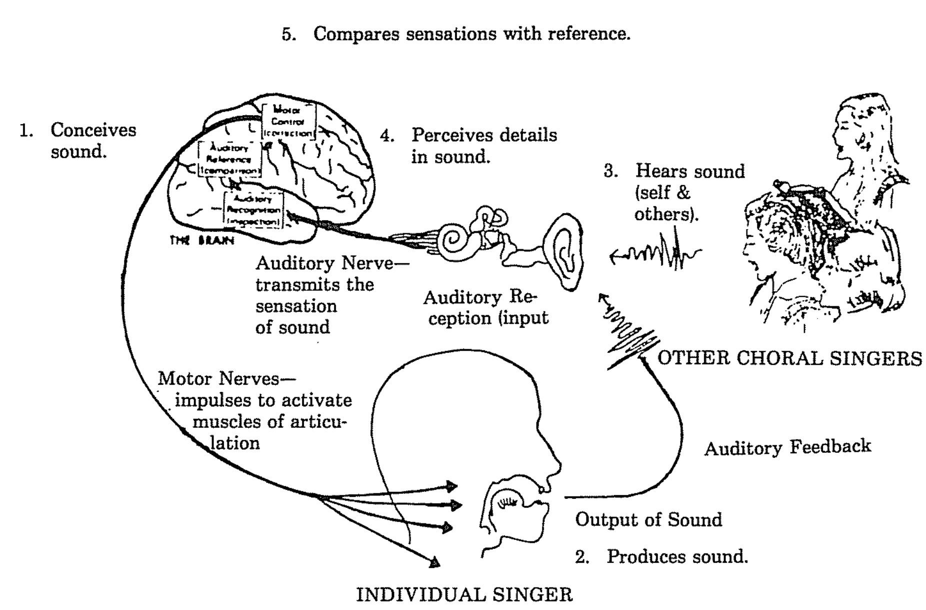

Fig. 1.— Schematic representation of cybernetic model of individual singer's task in achieving vocal blend with an ensemble.

On the surface it may seem like this is taking a rather routine musical task and making it needlessly complex. In fact, it is a complex task, and that it can be accomplished with such apparent ease by some individuals is a tribute to the marvelous capabilities of the human brain and nervous system.

"But," it might be asked, "would not directing attention to such minute details of the process be confusing, if not impossible, for singers just trying to blend?" Perhaps this would be so, assuming that the theoretical concepts could even be learned by the ordinary choral singer without a whole course of instruction devoted to them. The point, however, is that an understanding of the basic features in the process makes it possible for choral directors to structure rehearsal procedures, singer placement, and related activities so that the principles are taken into account by the choral singers without the singers necessarily having to be aware of them. Exercises, drills, and similar activities can be designed to incorporate practice of the vocal and perceptual skills pointed out by the cybernetic model.

Choral Rehearsal Ideas

The rehearsal ideas presented in this section are confined specifically to choral blend for purposes of clarity and brevity. Other aspects of choral sound, tone, for example, could be approached similarly.

Suggested approaches are presented for difficulties arising at each step, or phase, in the feedback loop, illustrated by the cybernetic model in Figure 1. The order in which the rehearsal ideas are presented is not a suggested order for using the techniques in rehearsal. The numbered "steps" merely refer to the numbered stages of the feedback loop. Familiarity with the cybernetic concepts explained in the first part of this article is assumed.

Many of the ideas presented are common rehearsal techniques. However, the manner in which they achieve desired results may be better understood by viewing them in the context of cybernetic principles.

Step one: the singer conceives the sound about to be produced.

Difficulty: The singer has no intended sound. He has little idea of what will happen until he sings and hears the result. Consequently, he sings without prior consideration of the sound (preinspection) and what prior adjustments might be made in order to assure that the sound produced will be acceptable.

Suggested approach: Develop activities that furnish singers with a mental conception of a sound (the remembered sensations of a sound just ended). Then require that they use that mental image as a target for producing a new sound (a reproduction of the aural image).

Have the singers produce a particular sound, stop, and then reproduce the same sound again as closely as possible. The same procedure might be followed for several contrasting sounds, after which the singers might be asked to reproduce any one of the sounds at will.

In a particular musical selection singers might be asked to produce a sound at one point which closely matches a sound produced at another point in the music. Singers could be asked to sustain a note, alter the sound in some way, stop, and then reproduce the sound that was last sung.

Approaches such as those above require singers to conceive a sound and then to produce the sound conceived.

Step two: the singer produces the sound.

Difficulty: The singer is unsure how physically to produce a given sound. The singer may know the kind of sound to produce, but he lacks the skill, coordination, or understanding to produce the sound which is conceived.

Suggested Approach: Basic vocal technique (breathing, phonation, resonation) should be reviewed with the singer if a basic problem is evident.

Have the singers experiment with changes in each of their articulators (mouth opening, lips, tongue), exploring the effects that certain articulatory positions have on the sound. Combinations of different articulatory positions should be tried in order to determine their effects on the sound.

Singers should be instructed to remember the positions of the articulators (the associated tactile and kinesthetic sensations) and the resulting sound (the aural sensation).

Step three: the singer hears himself and the other singers in the ensemble.

Difficulty: The singer is inattentive to the task of hearing because of distractions or preoccupations.

Suggested Approach: Make the singer aware of the problem. Appeal for cooperation for the group's sake ("team effort"). Singers' attentiveness to their own sounds might be improved by simply asking them to listen more closely to themselves.

Difficulty: The singer is preoccupied with the physical aspects of his own vocal production, and thus not listening to the sounds.

Suggested Approach: Identify the coordination problem of the singer and give personal aid in overcoming it. Encourage the singer to practice certain physical actions (breathing or open throat singing for examples) until they become automatic and no longer require conscious control.

Difficulty: The singers are preoccupied with pitch and rhythm or other musical problems.

Suggested Approach: Identify the troublesome aspects of the score and work separately for mastery of them before expecting singers to devote their main attention to tonal considerations.

Difficulty: The singer is tired physically.

Suggested Approach: Pace the rehearsal activities to provide a continuous interest. Encourage the singers to arrive at rehearsals fresh rather than fatigued. Permit the singers to sit or to alternate standing and sitting. Have the choir stretch or do light, localized calesthentics to stimulate circulation and deeper breathing. It may be necessary to change rehearsal time.

Difficulty: The singers lack a perceptive or critical attitude. They are disinterested.

Suggested Approach: Have the choir sing a sustained chord from a cadence point or another portion of the work under preparation and use every available means to make the choral sound like the goal which is sought in the work as a whole. Use that sound as a motivational device to let the choir hear a sampling of the sound they are capable of producing.

It may be advantageous to record and play back particularly well-performed portions of the work, thereby permitting the singers to get a "taste" of what the audience will hear. Poorly-performed portions may also be used. However, discretion must be used to insure that the singers do not become discouraged.

Issue a verbal challenge for the singers to listen more attentively. Arbitrarily shift the singers around into different positions so that the sounds heard by the inattentive singers are different than before.

Difficulty: The singer cannot hear the other singers adequately because of the masking effects of certain loud singers or instruments nearby.

Suggested Approach: Encourage the loud singers to sing at a lower dynamic level. Change the physical positioning of certain singers so that their adverse effects are minimized.

The too-soft singer should be encouraged to contribute more to the group sound, at least enough so that he can monitor his own voice adequately. A different physical positioning might help the singer hear himself better. Singers may have difficulty hearing themselves if they are positioned too close to one another, a situation that is especially likely to occur on crowded risers.

Difficulty: The physical positioning of the singers makes difficult their task of hearing themselves and the other singers. Perhaps the singers on the ends of rows cannot hear each other due to the precedence effect of intervening singers. The different choral sections may be separated by the particular choir loft or by other kinds of physical barriers. The physical arrangements of the individual singers with regard to each other or of the choral sections may result in hearing difficulties. The position of a singer's head may prevent him from hearing properly. This may result because of the angle required by the physical positioning of the singers in order for them to see the director. The position of a music folder held by an individual singer may serve as an acoustical barrier, preventing him from being heard adequately.

Suggested Approach: Experiment with different positions of the singers. Ask for the singers' ideas and suggestions in this regard.

Do not permit set positions of risers, acoustic panels, and other physical structures to dictate a fixed positioning of the singers. Let the stylistic characteristics of the score, such as ranges of parts, tessitura, harmony, and texture, suggest sectional positioning. Determine whether certain choral sections need to hear each other more than do other sections for a given musical work. Take into consideration the possible effects of singer positioning on the sound reaching the audience.

Difficulty: The singer has a physical hearing impairment. For example, aural fatigue may occur in an extremely soft passage following an extremely loud one. Aural fatigue may also occur because of loud sounds occuring periodically in a given work, loud entrances of percussion and/or brass sections, for example.

Suggested Approach: Point out the cause of the difficulty to the singers and encourage extra effort in listening. Changes of physical positioning may help, if such changes are possible.

Difficulty: The singer has a temporary medical hearing loss, associated with a cold, allergy, or earwax. The singer may have a permanent medical hearing loss because of an injury or a congenital defect.

Suggested Approach: Encourage singers identified as having medical hearing losses to have their hearing checked or to seek medical attention.

Step four: the singer perceives details in the sound which is heard.

Difficulty: The singer hears the sound of the group and of himself but is unable to distinguish certain aspects of pitch, vibrato, loudness, vowel quality, or timbre. This may be due to inexperience, lack of training, or poor natural ability. The singer may be "sound bathing" or daydreaming rather than inspecting the sound for details. The singer may be "deaf" to his own vocal faults.

Suggested Approach: Provide experiences in perceiving and discriminating certain details of choral sound through the use of recordings or singing exercises, possibly drawn from the musical score under rehearsal. Such activities should provide the singers with clear examples of those details in the sound which it is desired for them to perceive, such as the quality of particularly troublesome vowels. Both good and poor characteristics for the singers to evaluate should be presented in the activities.

Assess the singers' understanding by asking direct questions regarding the aspects of sounds presented. Try to establish that the singers are able to perceive certain details of sound before expecting them to be successful in subtle modifications of their own vocal sounds.

Step five: the singer evaluates the blend of his own voice with the ensemble.

Difficulty: The singer has little or no conception of what constitutes a vocal blend. The singer does not have stored in his auditory association area (memory of aural sensations) the sensations which are experienced by a singer when blend is achieved. There is no "target experience" concerning blend, no internal reference by which to measure the extent to which blend is achieved. The singer may be "trying," but without a clear goal, his efforts are random and only partly successful. The singer may recognize that something is wrong with his blending effort, but he cannot identify what it is.

The singer's difficulty may occur from lack of experience, that is, the situation has not been encountered often enough for the singer to develop an appropriate response. The situation in which he is asked to blend baffles him, and he does not know how to proceed. Resultingly, he may proceed in a random or trial-and-error manner.

Suggested Approach: Provide experiences for the singers which demonstrate what vocal blend is. A concept of blend from the perspective of the listener may be developed through playing recordings exemplifying various degrees of blend. Singers may be asked to identify those places in the music where they judge the blend to be greatest and least. The singers might be further questioned concerning those aspects of the sound which they perceive to affect the blend either positively or negatively.

Devise blending exercises (possibly portions of a musical work at hand, even a single note) and coach the singers until a suitable blend is obtained. In this way the singers can experience the aural sensations associated with achieving vocal blend.

Provide opportunities for the singers to experience different kinds of blending problems and to respond with appropriate actions. This means having singers approach blending in situations incorporating different pitch levels, vocal ranges, vocal registers, vowels, fixed and changing dynamic levels, texture, and so on. Effective exercises may be adapted from the music under preparation.

Additional Techniques

There are additional techniques which incorporate cybernetic principles which may also be useful. It is common for directors to work for a good blend on particular vowels by having the choir sing a single note or chord, listen carefully, and change the vowel or vocal quality until unity is achieved. Often, however, the blend which is achieved on the exercise is lost when the choir sings the text of the music.

The problem is that the positions of the articulators (mouth, lips, and tongue) are different for the blending exercise than for the music text. The later positions are already incorporated into the singers' habits so that those positions are automatically used when the words are read from the music page. Viewed in the context of cybernetic principles, the task is to identify those articulatory positions which are helpful for producing vocal blend in the exercise and to "program" them into the singers' singing/listening mechanisms.

One way that has been found helpful for doing this is again borrowed from the speech therapists. First, coach the singers to the desired blend for a certain vowel on a single note or chord, making sure that the singers are expecially conscious of the sound and of the positions of the articulators. Then immediately have the singers use the same articulatory position for singing a list of words consisting entirely of the vowel sound under consideration. For example, the vowel "ah" might use hot, job, cot, palm, drop, and so on. Insure that the singers use exactly the same articulatory positions for the list of words as they do for the vowel isolated in the exercise. In the music being rehearsed take all the words or syllables having the same vowel sound and incorporate them into the list of words sung. A few minutes practice in each choir rehearsal can over several rehearsals produce amazing results quickly.

Often the newly learned articulatory positions are not used when the choir sings certain successions of vowels as they occur naturally in the text of the music. The choir may sing the vowels properly when the vowels are sung in isolation and also, perhaps, in lists of words containing identical vowel sounds. But when singing different vowels in succession, the old, well learned positions return because of habit. There is a way of dealing with this problem.

After the singers can successfully maintain their blend on lists of words for several different vowel sounds — an "ah" list, an "oo" list, and an "ee" list, for example — then they should practice singing a word from one vowel list followed by a word from a different vowel list. This approach seems to be more effective than merely vocalizing on different vowels in succession, as, for example, the familiar "may mee mah mo moo" technique. Somehow movement to the appropriate articulatory positions is better learned by association with reading words containing the vowel sounds. Possibly this is because reading the words more closely approximates the actions involved in choral performance than does an exercise on vowel sounds isolated from words.

Summary

The basic task in any situation where choral sound is being developed is to change the vocal output so that the desired choral sound emerges. In designing rehearsal activities, the interrelated processes of vocal production and aural perception must be considered, for the aural mechanism monitors and indirectly controls the vocal mechanism. Since the various sensations associated with a given sound are stored in different memory areas of the brain, some means must be used to store "target sensory experiences" in those memory areas. Cybernetic techniques, successfully used by speech therapists to change clients' speech habits, may provide new ideas for the choral director to use in developing choral sound.

BIBLIOGRAPHY

1. Denes, Peter B. and Elliot N. Pinson, *The Speech Chain,* Garden City, New York, Anchor Press, 1973.
2. Fairbanks, G., "A Theory of the Speech Mechanism as a Servo-System," *Journal of Speech and Hearing Disorders,* (1954) 19: 133-139.
3. Fisher, Hilda B., *Improving Voice and Articulation,* Second Edition, Boston, Houghton Mifflin Company, 1975.
4. Fulton, J. F., editor, *A Textbook of Physiology,* Philadelphia, Saunders, 1955.
5. Mysak, Edward D., *Speech Pathology and Feedback Theory,* Springfield, Illinois, Charles C. Thomas, 1966.
6. Van Riper, Charles and James Irwin, *Voice and Articulation,* Englewood Cliffs, New Jersey, Prentice-Hall, 1958.
7. West, Robert, "The Neurophysiology of Speech," *Handbook of Speech Pathology and Audiology,* ed. by Lee Edward Travis, New York, Appleton-Century-Crofts, 51-60.
8. Wiener, Norbett, *Cybernetics,* New York, Wiley, 1948. ■