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PRINCIPLES OF SKILL ACQUISITION APPLIED TO VOICE TRAINING

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As a young vocalist and voice trainer, I kept thinking that if I could only identify the "right technique," if I could only figure out with certainty which body part should go where during voice production, then I could sing well and I could also be a good voice trainer. Even beyond the rather frightful omission of emotions and art in this thinking, there was a serious fallacy: knowing that you should hike up your larynx to your eyeballs when you sing (if that were the conclusion) is not equivalent to knowing how to do it or how to teach it. In fact, even as my knowledge of voice physiology increased, my ability to "do it" and to "teach it" was not necessarily improved proportionately. A gulf remained between my explicit, analytical knowledge about voice, and voice production itself. At first, the gap annoyed and perturbed me. Then it became interesting. What was the nature of "learning how"? How was it different from "learning that," or "book learning"? These and other questions prompted me to pursue studies in skill acquisition in a department of psychology.

As luck would have it, during the same historical period in which I initiated those studies, a theoretical approach to learning and memory was developed that focused on the very distinction that intrigued me: the distinction between "knowing that" and "knowing how." Based on observations of amnesic subjects as well as normal learners, it was proposed that there are different memory systems or information processing modes with distinct neuroanatomical and cognitive substrates: one system or mode that governs "knowing that" and one that governs "knowing how."

Few subjects could have been more interesting to me. This essay is an attempt to summarize in a simple way what I consider to be among the most important findings on this topic and on skill acquisition in general, as they may apply to voice and voice training.

Throughout this essay, I repeatedly refer to "memory system" and "processing mode" side by side. The reason is that a debate has been going on for a few decades now about whether to consider memory structurally, as a "system," or whether to consider memory dynamically, in terms of its processing characteristics. My use of the terms "memory system" and "memory processing mode" in the same document reflects my decision to acknowledge both theoretical views equally, essentially because I think both have merit, and I think that the distinction is an artificial one.

Some leaps will be necessary. Most of the experiments have been done using verbal or hand-eye coordination tasks. None have been carried out using voice tasks. Also, most of the experiments investigating the cognitive characteristics of the memory type we are interested in have been carried out not looking at skill acquisition per se, but rather at a parallel phenomenon called "priming," which will be discussed in some detail shortly. Despite these limitations, I think that it is reasonable to make some generalizations from these studies to skill acquisition in voice training, awaiting the proper studies.

THEORETICAL BACKGROUND

Among the earliest contemporary observations leading to a distinction between "knowing that" and "knowing how" were those reported by Dr. Brenda Milner, a Canadian neurologist. A patient of hers, a now-famous "H.M.," had undergone a bilateral resection of his temporal lobes (parts of the brain surface) as treatment for a debilitating seizure disorder. After his surgery, H.M. could not acquire new, conscious memories of post-surgical events. He did not remember from one moment to the next that he had eaten or that he had met someone. Somewhat surprisingly, he could remember how to do new things. For example, he improved with practice on a task that required tracking a rotating target with a wand.[1] So, he was indeed able to form new memories: those governing improved perceptual-motor performance with practice. He just did not know that he had acquired the memories. (In fact, a "memory" is any record of the past, regardless of whether the memory is "remembered," or experienced in consciousness, or not.)

The theoretically important implication that eventually developed from this report and similar ones was that there must be a neuroanatomical system or processing mode that governs practice effects without conscious remembering, and that is spared in amnesia, as well as a system that governs memories that we experience and can talk about. The brain parts resected in H.M.'s surgery, and specifically the hippocampus and the amygdala in the temporal cortex, were clearly important for the latter but not the former type of learning and memory.

What are the characteristics of the memory system (or processing mode), preserved in amnesia, that appear to govern perceptual-motor skill acquisition? Information about this system and how it works might elucidate some useful principles for voice training. A look at some recent findings will shed some light on this question.

Characteristics of the Memory System and Operations Preserved in Amnesia, Which Appear to Govern Perceptual-Motor Skill Acquisition, i.e., "Implicit Memory"

The memory system (or processing mode) preserved in amnesia governs not only skill acquisition for perceptual-motor tasks, but also other, functions, including `riming;" Priming is facilitated performance on previously encountered stimuli, as compared with performance on new stimuli of the same class. For example, if a subject first studies a series of words and then is shown studied and non-studied words extremely rapidly (say 35 ms. [milliseconds] each), priming is shown by better identification of the studied versus the non-studied words, regardless of whether the subject remembers the studied words or not.

So, to reiterate, both skill acquisition and priming remain intact in amnesia; as such, they can be considered together as part of a set of memory functions called "implicit memory," or to use Squire's term, "procedural memory." Specifically, implicit memory is reflected by any performance benefit from prior practice or exposure to stimuli, without learners explicitly remembering those stimuli (Graf & Schacter, 1985; see also Schacter, 1987, and Roediger, 1990, for excellent reviews). Not only amnesic learners but also neurologically intact subjects show implicit memory, as described next. In the discussion that follows, we will assume that the characteristics of implicit memory—most of which are known from studies on verbal priming—are consistent across all types of implicit memory, including perceptual-motor performance without awareness. This assumption may ultimately be shown to be incorrect, but I am willing to make it in the meantime.

Implicit Memory is Memory Without Awareness

Implicit memory, as it has been defined in theoretical research, is memory without awareness. That is, implicit memory involves a memory type without conscious remembering of events leading to memory development or conscious remembering of what has been learned. At best, conscious awareness is irrelevant for implicit memory. At worst, it may interfere with it (Verdolini-Marston, 1991).

Given this characteristic of implicit memory, it would seem that this memory type could be shown only in amnesic subjects, who do not remember much of anything. On the contrary, implicit memory can

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[1] Antecedent observations were made as early as Plato (see for example, Stumpf, 1975) and Descartes (see Haldane & Ross, 1967), and were later made by psychiatrists (Freud & Breuer, 1966; Janet, 1893, 1904), psychologists (Ebbinghaus, 1885; Hull, 1933; Thorndike & Rock, 1934), neurologists (Clarapede, 1911/1951; Korskoff, 1899), and others (see Schacter, 1987 for a review). However, Milner's reports more directly led to the current formulations discussed.

also be shown in normal learners. Graf and his colleagues (Graf, Handler, & Haden, 1982) reported a classic study in this regard. In that study, the investigators essentially simulated amnesia—and showed implicit memory—in neurologically intact learners.

Healthy adults were first asked to study a list of words (for example, they might have been asked to study "defend, repair, engage" etc.). Subjects were later asked to complete word stems (for example, "def ") with the first word that came to mind. Each stem could be completed with several different words ("defend, define, default... "). However, subjects tended to complete the stems with previously studied words, *which they did not necessarily remember,* at a greater than chance level (priming). Thus, the effect of prior exposure was seen on current performance, without the apparent assistance of conscious remembering. This finding constituted evidence of implicit memory or memory without awareness in normal learners.

Implicit Memory Appears Fundamentally Governed by Perceptual Processes

This point is the most important one to focus on regarding implicit memory, to my thinking. Implicit memory, at least as reflected by priming, fundamentally involves the mental processing of perceptual—or sensory —information: sight, sound, smell, taste, and touch. As important, implicit memory generally does not appear to involve "associative processing," or the relating of perceptual information to other mental contents and operations that make it "meaningful" or symbolic.

The study cited above by Graf and colleagues is an example of the many, many experiments that have pointed to this conclusion (Graf et al., 1982). Recall that in the initial phase of that investigation, subjects studied a list of words. In fact, during the study phase of the experiment, subjects studied the words under different conditions. In one group, subjects studied the words by processing their meanings (subjects rated how much they "liked" each word, related to its *meaning*). In another group, subjects studied' the words by processing their perceptual or *surface* characteristics (subjects indicated whether each word had any letters in common with the preceding word).

During the subsequent test phase of the experiment, it turned out that the likelihood of remembering or recalling the studied words was increased if the subject had processed the words' meanings during study. However, the likelihood of spontaneously completing a word stem with a previously studied word (or implicit memory) was unaffected by the earlier study task: words that had been examined for their meaning and words that had been examined for their surface or perceptual characteristics were equally likely to be produced as word stem completions, even when subjects did not recall which words they had studied. The conclusion was that implicit memory (reflected by word stem completion in this case) can develop any time one is exposed to a stimulus and processes its perceptual characteristics. The processing of stimuli's meanings, or associative processing, appears irrelevant for the development of this memory type. Numerous other studies have pointed to similar conclusions, although qualifiers do need to be added. One qualifier is the topic of the next subsection.

Implicit Memory Requires Attentional Processing

Some studies have pointed to the likelihood that when *new* stimuli are encountered, for effective perceptual processing underlying implicit memory to occur, full _attention must be directed to the stimulus. This principle was perhaps most clearly demonstrated in a series of studies by myself, for my dissertation (Verdolini-Marston and Balota, 1994).

My studies involved a perceptual-motor task, "pursuit rotor." In this task, the object is to track_ a rotating stimulus with a wand. When there is contact, a counter is driven. If the subjects involved were amnesic subjects who did not remember that they had ever done the task before, improvements with practice would constitute evidence of implicit memory, i.e. memory without awareness. However, we used neurologically normal subjects in our studies, who did remember that they had done the task before from session to session. Thus, to investigate implicit memory, we had to come up with some measure of perceptual-motor learning without awareness in these normal learners. We essentially used a priming paradigm. Subjects first practiced on several different stimuli. Later, they returned for a test on the old stimuli, as well as on new stimuli of the same difficulty. Implicit memory would be shown by a performance benefit for the old as compared with the new stimuli, assuming that subjects did not remember which stimuli were old and which were new. In our first of several experiments, we demonstrated such priming for the pursuit rotor task.

The main objective of theoretical interest in our studies was then to investigate the type of mental processes that regulated priming for this perceptual-motor task. We thought that priming might be governed by perceptual processes, as had been found for verbal priming. Our experimental strategy was to give subjects in different groups different instructions about what to do mentally during the initial practice phase. In some groups, subjects were instructed to use images to assist their performance, such as stirring in a bowl or imagining a locomotive wheel as it turned. (According to earlier pilot work, subjects thought that these were good images to help performance.) In other groups, subjects were instructed to pay attention to the task, and to concentrate on it. Finally, in other groups, subjects were not given any instructions about what to do mentally during practice.

During the later test phase, it turned out that subjects showed priming (a performance benefit for old stimuli, without remembering which stimuli were old, or implicit memory) only if they had not been given any instructions about what to do mentally during practice. Subjects who had received instructions, whether they were imagery or concentration instructions, failed to develop priming or implicit memory.

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We were a bit perplexed by the findings, but our explanation was ultimately as follows: perceptual processes underlie implicit memory in the perceptual-motor as in the verbal domain. However, for tasks that are novel to subjects —such as the pursuit rotor task—in order for perceptual processing to occur, subjects must devote their full attention to the task. (Perceptual processing might occur more automatically for familiar stimuli, such as words.) When instructions of any type were imposed, subjects paid attention to the instructions, and not to the perceptual array associated with the task. Thus, priming (implicit memory) failed to develop.

What we have said here may seem to be a paradox: implicit memory involves learning without awareness, yet attention is required. How can we be Unaware of various aspects of a task, and yet attend to it? Thinking carefully, awareness and attention are actually different phenomena. Awareness involves knowing that one has done something specific (performed on a given stimulus, or perhaps moved the arm this way or that way). Attention. Refers to alertness, or the reception of information without any necessary conscious organizing of it in time or space. In a word, attention refers to "being in the moment," "being here, now," without judgment or comment or conclusions (awareness).

Another important finding in our studies, which may be of greater interest for this readership, was that not only implicit memory (priming, in this case) but also learning for the pursuit rotor task in general was poorest when subjects were given mental strategies to use during practice. Relatively poorer overall performance was seen for both imagery and concentration groups, as compared with the no-instruction group. Equally as interesting, subjects who used imagery and concentration strategies thought that those strategies were very helpful for learning and performing the pursuit rotor task. The implication is that imagery instructions or even concentration instructions may not be as useful as we sometimes think they are, regardless of students' informal impressions about their benefits.

Implicit Memory Depends on Repetition

One of the strongest factors affecting implicit memory is repetition. The size of performance benefits for previously encountered or practiced stimuli increases as the number of exposures or repetitions increases. This principle seems obvious enough, so I will not drag you through the evidence (the interested reader is referred to Jacoby and Dallas, 1981). However, as noted in the preceding sections, for repetitions to be effective in producing implicit memory, apparently they must involve the processing of perceptual, or sensory information. The repetitions must also occur in the same modality as will be required for later tests of implicit memory. This issue is discussed next.

Implicit Memory is Modality and Context-Specific

Implicit memory appears to be a quite literal and inflexible memory type in that it is modality-and context-specific. If you change the performance modality between study (training) and test (for example from the auditory to the visual modality), or even if you change the environment in which study (or training) and test occur, (from a swimming pool gallery to a games arcade), implicit memory fails to develop normally.

An example- of the modality-dependence of implicit memory was reported by Jacoby and Dallas (1981). In one of their experiments, words were presented to subjects either visually or auditorily during an initial study phase. In a later test phase, subjects were required to identify words that were presented visually, extremely rapidly (for 35 ms). Some of the test words were from the earlier study list and some were not. A better ability to identify studied as compared with non-studied words would constitute evidence of priming or implicit memory. In some cases the modality was consistent between study and test modality (visual-visual), and in some cases 'Modality was inconsistent between study and test (auditory-visual). On average, subjects showed better identification of studied as compared with non-studied words (implicit memory), *provided* that the study and test modalities were consistent (visual-visual). When study and test modalities were inconsistent (auditory-visual), implicit memory was not shown. The implication is that implicit memory depends on modality consistency between training and later performance.

Implicit memory also fails to develop fully when the context (or environment) changes from study to test. An example of this principle was reported by Graf (1988). In his study, subjects studied the usual word list during an initial experimental phase, either in a swimming pool area or in a games arcade. Later, subjects performed on implicit memory tests (word stem completion and another conceptually similar test, a "category production" test), either in the same setting in which they had studied or in the other setting. Priming, or implicit memory performance, was greater when the study and test environments were consistent. Thus, implicit memory depended on environmental consistency.

OTHER PRINCIPLES OF SKILL ACQUISITION

There are numerous other important principles of skill acquisition that have been investigated within other frameworks besides implicit memory. Schmidt (1987) provides a comprehensive review of this literature and pertinent issues. For our purposes, three of what I consider the most important principles are discussed next.

Skill Acquisition Requires Information About Performance During Training (Knowledge of Results)

For skills to improve with practice, learners must have information ("knowledge of results," or KR) about how well they have done relative to the target performance. An example of this quite intuitive principle was illustrated in a study by Bilodeau and colleagues (Bilodeau, Bilodeau, & Schumsky, 1959). In their study, subjects practiced what is called a "linear positioning task," which requires subjects to learn to displace an object to a criterion position. Some subjects received KR after each of twenty practice trials, some subjects received no KR for twenty trials, and other subjects received an intermediate amount of KR. The result was that no learning was observed in subjects who had not received information about their performance, or KR. Therefore, KR was apparently required for learning.

The interesting thing is that, from this and other studies, although KR appears required for learning, more is not necessarily better. In another study by Johnson, Wicks, and Ben-Sira (1981), using a similar linear positioning task as in the study by Bilodeau and colleagues (Bilodeau et al., 1959), some subjects received KR after each of ten trials. Some subjects received KR on 25 percent of forty trials, and some subjects received KR on 10 percent of one hundred trials. Thus, in each subject group, subjects received KR on ten trials. However, there were differences in the number of intervening trials between KR provision. During the training phase of the experiment, subjects who received relatively infrequent KR appeared to do somewhat worse than other subjects. However, when subjects were tested later, during a delayed test, subjects who had received the infrequent KR actually did the best.

The implication is that although frequent KR may be useful for *immediate performance during training*, less frequent KR may enhance actual learning shown by better performance at a later time. It may be that when learners are not pounded with KR during training, they can process information relevant for learning and "make it their own," with performance benefits at later follow-up.

To be able to perform acquired skills along with other tasks, consistent responding is required during training. One of the goals of training in many domains, including voice, is to skillfully produce the target behavior while at the same time performing other critical tasks, for example talking, moving, or dancing. Some work suggests that the ability to run a new, acquired behavior off skillfully along with other behaviors requires that during training, the behavior be consistently produced in the target fashion. This principle was evident from a series of studies by Schneider and Fisk (1982). In their studies, subjects were first shown a series of cards with letters on them, in rapid succession, and were required to indicate in which position on a card a target letter had appeared. In some cases, a given letter (for example, "M") was always a "target" when it appeared. This was called a "consistent mapping" condition. In other cases, a given letter ("M") might be a target to watch for on one trial, but not a target on the second trial (i.e., "X" might have been the target, and "M" a distraction). This training condition was called "variable mapping." Later, the task was made more complicated by asking subjects to look for new letters as well as previous target letters. The result was that when this additional task was added, subjects were able to retain their previous skill level in position identification for the original target letters only if previous training had involved consistent identification of those letters, or "consistent mapping." If previous training was inconsistent, or variable (requiring the identification of different letters on different trials), earlier skill levels were not retained in the face of the new task. An excellent way to summarize the conclusions from this study is found in a much earlier quote by a renowned American psychologist, William James:

> *Never suffer an exception to occur till the new habit is securely rooted in your life*. Each lapse is like the letting fall of a ball of string which one is carefully winding up; a single slip undoes more than a great many turns will wind again. Continuity of training is the great means of making the nervous system act infallibly right. (James, 1890).

Generalization to untrained variants of tasks is enhanced by practice under variable conditions. Practice under variable conditions appears to enhance the generalization of specific trained behaviors to other behaviors in the same class. An example demonstrates this principle. McCracken and Stelmach (1977) had subjects practice knocking over barriers with their hands within a given time-period on numerous trials. Some subjects received practice with a constant hand-to-barrier distance, and other subjects received practice with different hand-to-barrier distances on different trials. During the training phase, subjects with the constant distance did better. However, when all subjects were tested later with a distance that was new for all of them, those who had previously received variable practice did better.

The point from this and other studies is that to maximize the generalization of a trained behavior to new, untrained situations, practice should involve varied practice conditions, perhaps with varied materials.

APPLICATIONS TO VOICE AND VOICE TRAINING

Having gone through some of the details, what do we do with this information in voice and voice training? In this next section, we take a second look at each of the principles discussed above, one by one, and try to make some links to voice and voice training. Then in the final section, we attempt to tie all the principles together into a cohesive whole.

You may discover that you already employ several of the suggested strategies. In this sense, the following section might provide support and encouragement for what you are already doing.

Specifics

Implicit memory is memory without awareness. Based on studies with amnesic subjects, implicit memory is a memory system or processing mode that appears to govern skill acquisition and does not involve conscious awareness of what has been learned. In fact, awareness may be indifferent for implicit memory. Explicit knowledge about learning contents may actually interfere with the development of implicit memory, in some cases (see for example, Verdolini-Marston, 1991).

The implications might be quite surprising to some trainers: although knowledge about voice science may be extremely helpful to you as trainers, that knowledge is not necessarily helpful to your voice students. In particular, *a mechanistic awareness about voice production in training, such as "expand your ribs- here and drop your jaw there" may be fruitless or even counterproductive*. I realize that this is a strong statement, and may not extend to all situations. However, I encourage you to explore it.

Implicit memory appears fundamentally governed by perceptual processes. From this principle, we understand that one of our main tasks as trainers is to promote our students' processing of perceptual—or sensory—information during training. We should show students what good alignment for voice production looks like. We should let them feel a deep breath. We should let them hear the sound of a focused voice.

The emphasis on sensory information is not new to theatre. The Alexander Technique is profoundly based in this principle (see for example, Jones, 1976). Lessac also focuses on sensory information, going so far as to include "tasting" and "smelling" various aspects of voice production (Lessac, 1967). There are many, many other examples of theatre trainers for whom sensory information is a critical part of the training program.

A discomforting corollary is that metaphoric images ("imagine rowing a boat as you breathe"), which are commonly used in voice training and which involve meaningful or associational processes (as opposed to perceptual processes), may work against voice development in some cases.

Implicit memory requires attentional process, where novel stimuli are concerned. The implication from this principle is that any operations that divert away attention from perceptual or sensory information related to voice may interfere with memory development. Attention can be diverted by too many instructions about mental strategies, so that the learner attends to the strategies and not to sensory information. Attention from perceptual information can also be diverted by emotional responses. ("That was so *terrible!!!* — foot stamping optional). Attention may be affected by low motivational levels. Most of you are empirically familiar with these and other apparent perils to attention.

As already mentioned, I think that the best way to describe what attention to perceptual information "looks like" is "being in the moment," "being here, now." Theatre trainers are all assuredly very familiar with this concept.

Implicit memory depends on repetition. This principle is quite straightforward. PRACTICE! Or, as Lessac (1967) suggests, "Don't practice, do it!" (repeatedly).

Implicit memory is modality- and context-specific. Here we have an interesting point. There has been much talk about different "modality" strengths across learners in theatre training. According to this view, some people would be "visual" learners. Others would be "auditory" learners. Still others would be "digital" or verbal learners. The suggestion is to modify your teaching input to match the student's modality strength. The finding that implicit memory is modality-specific suggests a different tack. Within this framework, the best modality for training is the modality required for task execution. For voice production as for any motor task, ultimately, perceptual (not verbal) information guides central nervous system output commands. Therefore, training should occur in the perceptual realm, including auditory, kinesthetic, and visual modalities, depending on the specific task. If we train a student in the "digital" or verbal mode, at best a translation of that information to a perceptual code will be required before voice can be produced; the transformation takes time and precious information may be lost or distorted in the process. The verbal mode is right if you want the student to learn to talk about voice production. But the verbal instructional mode is wrong for voice training, if you want the student to actually learn to produce voice better, *regardless of the student's relative "modality strengths*.

Also, training benefits may be greatest when training occurs in the same or similar environments as will be encountered for performance. We all think about conducting classes on a stage, but I for one do not do it nearly enough.

Skill acquisition requires information about performance (knowledge of results). Students need information about how they are doing relative to what you want them to do. However, intensive feedback is not necessarily good. (Withholding information about performance for several trials may enhance / the student's own processing of information and later performance, or. learning. This conclusion may be especially valid later (as opposed to earlier) in learning. So, not giving any feedback for several trials may help the student generalize from what you have worked on for one vowel to another vowel, from one monologue to another, and so forth. The translation of this principle to simpler language is, "Give your student space!"

To be able to perform acquired skills along with other tasks, consistent responding is required during training. I have heard theatre trainers talk about this principle: if the student is to use a certain voice production mode on stage while acting, dancing, emoting, etc., that same mode or a similar mode must be consistently used, even offstage. What it boils down to is that we cannot summon a physiological operation in voice on stage, adding other task requirements, if we do not consistently use that mode in all or most situations when it is appropriate.

Generalization to untrained variants of tasks is enhanced by variable practice. The use of varied training materials will probably enhance the student's ability to generalize a target voicing mode from trained to untrained materials. For example, if you are working on a focused voice, you should train it on many different vowels, phrases, monologues, etc. In that way, when the student encounters new materials, generalization of focused voice should transfer to those materials. Similarly, you should include different performance materials in training: different monologues, dialogues, comic and tragic material, etc.

TYING IT INTO A COHESIVE WHOLE

For a few years, I found myself incorporating many of the principles described here in a helter-skelter fashion in voice training. My mind leapt from one to another to another of the principles, like the proverbial monkey in a tree. I was run ragged by the job, and my students and patients were probably stunned. What was the classic "banana" that would quiet the mental monkey? If we accept the principles discussed here, how can we tie them all together into a cohesive whole? Let me share what I have come up with so far.

The kingpin of what I call my "skill acquisition package" is the notion that skill acquisition fundamentally involves *attention to perceptual information*, in numerous repetitions, with varied tasks. If the student effectively processes perceptual information, several of the principles that we discussed will be satisfied as a by-product. We avoid a mechanistic "awareness" of voice production. We stay in the relevant modality, which is perceptual, not verbal. Numerous repetitions occur, with consistent performance required across different tasks. An additional notion is that I attempt to supply "some" but not "too much" feedback (knowledge of results).

What does all this look like? I have a hierarchy of five steps that I think represent a start. Let us take breathing as an example. Say that we want the student to expand the abdomen on inspiration, and press it in during expiration (and voicing). How can we get the behavior trained, following the principles outlined? The steps that I use are:

Step 1. *Direct the student's attention to the-body in general*, and ask him to notice any-sensations. ("Scan your body with your mind's eye. Do you notice any sensations?") Do not ask the student to describe the sensations verbally, just to a Often; the Desired physiological behavior will appear with this simple step, without further work. If not, proceed to Step 2.

Step 2. *Direct the student's attention to the specific body part of interest*, in this case, the abdomen. ("Focus on your abdomen as you breathe.") Again, the desired behavior may appear with this step. If not, proceed to either Step 3 or Step 4 (they are interchangeable in order).

Step 3. *Model* the behavior for the student. For example, without saying anything, place the student's hand on your abdomen as you breathe in and out.

Step 4. *Manipulate* the student's body so that the target behavior is likely to occur. In this case, you might stabilize the shoulders and chest so that only the abdomen is available for movement during breathing:

If the student still does not produce the behavior, as an absolute last resort, proceed to Step 5, which violates the principle of perceptual training:

Step 5. Tell the student what to do.

This sequence, which I think I came up with on my own, has a similar flavor to what Timothy Gallwey describes in his book on tennis learning, *Inner Game of Tennis* (1974). In that book, he also emphasizes the processing of perceptual, or sensory information. The sequence that I outlined can J be used with just about any behavior that you want to train. If a student is "squeezing" in the throat while talking, direct the student's attention to the body in general, and ask her to notice any tension. If the tension does not dispel, direct her attention to her throat. If that does not work, model tight versus free voice, and have her mimic you in both. Or, manipulate the neck or other body parts in a way that is likely to free the throat. Finally, if you must, tell her to let go of her throat, for heaven's sake.

Once the student has produced the behavior for simple tasks, you proceed (of course) with many, many repetitions, in different and increasingly complex contexts (for example, simple vowels, words, phrases, short discourse, conversation, monologues). Gradually fade models so that the student depends less and less on your input.

With this type of sequence as a part of your training technique, you will discover that you are talking and explaining less and less, and "doing" more and more. Bonnie Raphael referred to this principle at a recent VASTA workshop (1993), "Every year I promise myself, 'Half as many words.'" I agree with her, and consider minimized yammering an indication of principled and, I think, effective training.

SUMMARY

In this essay, we have discussed several principles of skill acquisition, mostly derived from a theoretical construct called "implicit memory." This type of memory, to which skill acquisition appears tightly linked, is a memory without awareness, it involves attention to perceptual or sensory information;

and, it develops with numerous and consistent modality- and context-specific repetitions of target behaviors. It is optimal training for voice performance since it likely maximizes attention to sensory information, minimizes verbal analytic explanations, and includes training with a variety of materials and in physical environments that will be relevant for performance. The approach described here is, in sum, "something to experience."

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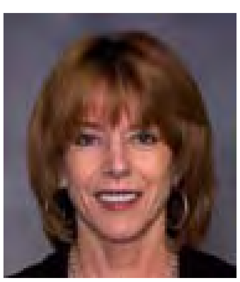
This biographical material below has been added for informational purposes. It is from: University of Pittsburgh, School of Health and Rehabilitive Sciences: *http://www.shrs.pitt.edu/CMS/School/Faculty_Bio.asp?id=76*



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Research Interests

Clinical voice science
Voice biomechanics (*in vitro, in vivo, in silico*)
Vocal fold wound healing (*in vitro, in vivo, in silico*)
Cognitive neuroscience
Motor learning in behavioral therapy
Emotions and voice; mental and autonomic nervous system mediations
Metabolic issues in vocal fatigue
Clinical trials
Ergonomic factors in voice disorders

Biographical Profile

Dr. Katherine Verdolini Abbott is Professor Communication Science and Disorders in the School of Health and Rehabilitation Sciences at the University of Pittsburgh. She completed her doctoral training Experimental Psychology at Washington University in St. Louis in 1991.

Her general focus is clinical voice science. Her research has addressed numerous issues relevant to voice and its function, including the effects of hydration and dehydration on vocal performance and vocal fold tissue; laryngeal biomechanics; the influence of tissue mobilization on wound healing in the larynx; metabolic, emotional, and autonomic nervous system mediators of selected voice disorders; occupational and other risk factors for voice disorders; cognitive and neural substrates of motor learning and their relevance for voice therapy; and the effectiveness and efficacy of voice therapy for individuals with phonotrauma. Her work uses a combination of *in vitro, in vivo,* and *in silico* approaches.

She is the former recipient of a K08 Award from the National Institute on Deafness and Other Communication Disorders (NIDCD), from which she has also received two R01 Awards as Principal Investigator. She is Co-Investigator of an R21 Award (Dr. Edwin Yiu, P.I.) looking at the effects of acupuncture for the treatment of phonotrauma, from the National Institute of Complementary and Alternative Medicine.

Dr. Verdolini Abbott currently serves on the MFSR Study Section for the National Institutes of Health. She is Editor for Speech for the *Journal of Speech, Language, and Hearing Research.* She is a member and Fellow of the American Speech-Language-Hearing Association, and member of the National Association of Teachers of Singing and the Voice and Speech Trainers Association. She is a licensed speech-language pathologist in the Commonwealth of Pennsylvania.

Education

PhD Experimental Psychology, Washington University , 1991
MA Speech and Hearing Sciences (magna cum laude), Indiana University , 1982
MA (equivalent) Italian Literature, Universita' di Ferrara, 1978
BA Italian/German (with distinction), Indiana University , 1975 (Junior and Senior years at the Universita' di Bologna)

Recent Publications

Verdolini K. Critical analysis of common terminology in voice therapy: A position paper. Phonoscope, 1999;2:1-8.

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