BIOFEEDBACK AND LEARNING STYLES

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By Margaret M. Bedrin
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ABSTRACT

This study examined the possibility of enhancing and improving the benefits of biofeedback. The study provided for the investigation of matching or mismatching researcher instruction and biofeedback signal with a person’s preferred learning modality. It was hypothesized that learning of skin temperature biofeedback would be more efficiently accomplished when the feedback signals were matched to the subject’s preferred learning modality.

The sample consisted of sixty subjects who were either college students or members of the general population. Each subject participated in a fifty-minute session, which allowed for the assessment of an individual’s primary learning modality and a twenty-minute skin temperature biofeedback training session. The Swassing-Barbe Modality Index was used to identify the subject’s learning modality and a Cyborg P642 thermal biofeedback instrument was used to record fingertip temperature.

The significant finding that emerged from this study was that subjects who received matched researcher instruction and biofeedback signal demonstrated significantly larger skin temperature increases. Baseline temperature had no significant effect on the matching of modality and feedback signals. In addition, limitations of this study and recommendations for further research are also discussed.
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By

Margaret M. Bedrin

Approved:  

Robert M. Wells

Donald J. Strong

Date:  

August 1, 1989  

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Chapter 1

INTRODUCTION

Background

Biofeedback has been widely recognized as a useful and valid procedure. It has evolved from being a curiosity that employed clumsy electrical equipment which recorded physiological measurements, into a highly technological and innovative technique that employs sophisticated electrical instrumentation.

With the development of more usable and informative biofeedback equipment, biofeedback training has become more accessible to both individuals and professionals. In the professional realm, it has become quite useful as an adjunctive technique to verbal therapy, as well as being employed in the psychophysiological field for treatment of such disorders as Raynaud’s disease, stress and asthma, migraine headaches and essential hypertension. It has also become a standard and effective component of rehabilitative treatment in physical medicine.

The area of biofeedback is represented by such professional organizations as the Association for Applied Psychophysiology and Biofeedback, The American Association of Biofeedback Clinicians, and the Biofeedback Society of California. Research is published in such
journals as Clinical Biofeedback and Health and Biofeedback and Self-Regulation, as well as other professional journals within the psychological and medical fields. Such research presents biofeedback and biofeedback training as a useful and documented area within the scientific community.

Researchers have established that individuals can learn to control both their autonomic and visceral nervous systems with the aid of biofeedback (1968, Kamiya; 1970, Green; 1973, Budzynski & Stoyva). Thus by utilizing biofeedback training or procedures, individuals can bring about voluntary changes in their body functions. The word biofeedback stands for bio (body) and feedback (information). Biofeedback may be described as:

Information about an individual’s biological functions, which is provided by the use of a monitoring instrument (usually electrical) in order for a person to receive specific information about a certain physiological process. Such information can then allow a person to achieve bodily changes by gaining increased awareness and sensitivity to internal sensation (1981, Danskin & Crow).

Since biofeedback presents an individual with information or feedback about a body process or function, a person may learn to control such things as heart rate, breathing, blood pressure and brain waves. Such control or learning was not considered possible before the establishment of biofeedback techniques. Since learning is influenced by environment, as well as genetic factors, isolating or controlling specific factors in the environment
could enhance the learning process. Thus the learning phase of the biofeedback training procedure might be enhanced by optimizing any factor that might lead to more effective learning.

One such factor is the utilization of a person's primary learning modality. Swassing and Barbe (1979a) note that each of us has a preferred learning modality and that we use this modality in our learning process. They postulate the existence of three primary learning modalities.

The three learning modalities, which Swassing and Barbe have identified are auditory, visual and kinesthetic. If a person learns most readily by "seeing" information, they are said to possess a visual learning modality. If a person learns most readily by "hearing" information, they are said to possess an auditory learning modality. Finally, if a person learns by "doing or touching", they are said to be using their kinesthetic senses; they can be said to possess a kinesthetic learning modality. These researchers hypothesize that offering instruction or training in a way which capitalizes upon or makes use of a person's primary mode of learning should result in increased learning.

While Swassing and Barbe have investigated primary learning modality, other researchers have also investigated the concept of thinking styles or primary representational systems (1980, Dilts, Grindler, Bandler, Delozian & Cameron-Bandler). Bandler and Grindler (1979) postulate that people
think in one of three main representational systems which are visual, auditory and kinesthetic. Internally, they may be either generating visual images and possess a visual representational system; they may be talking to themselves or hearing sounds and possess an auditory representational system; or they may be using their tactile abilities and possess a kinesthetic representational system.

According to these theorists, one of the ways that these representational systems can be identified or known is to listen to the process words (predicates: verbs, adjectives and adverbs) that individuals use to describe their experience. For instance, a person might use visual words such as "look, see, show, focus and perspective" or a person might use auditory words such as "I hear what you are saying" or "that rings a bell". A person with a kinesthetic system might use words such as "in touch, sense and feel". Different people seem to have a tendency to think or process differently and these differences may correspond to three principal senses namely, vision, hearing and feeling.

Since learning requires the use of our thinking facilities as we process incoming information, it is not unreasonable to assume that a person’s primary representational system, which may affect his or her thinking style, relates to or may be associated with the way a person learns. Thus learning or the processing of information might be enhanced by offering instruction in a person’s primary learning modality.
Although the concept of a primary learning modality has not received a lot of research attention, instructors in educational settings often notice that students learn in different ways. Thus the method of presentation of information will often determine how quickly the information is learned and presentation in a different way might either enhance or interfere with the learning process. Knowing a person's strongest learning modality and then offering information in this manner, may result in decreasing the frustration and length of time that might be associated with the learning of this material. This might be accomplished by focusing on a person's modality strength preference (1979a, Swassing & Barbe). Taking these observations into consideration, it is reasonable to assume that people will learn more quickly if they are taught in a particular way. For instance, people should be able to learn biofeedback more quickly if the instruction and the feedback signal are matched to their primary modality.

Statement of the Problem

The purpose of this research study was to determine if the learning of biofeedback could be facilitated by offering individuals biofeedback training in their preferred method of learning. More specifically, could individuals more readily learn biofeedback when the biofeedback signal and researcher's instruction were matched to their system.
Skin temperature biofeedback training was used to investigate this procedure. It was hypothesized that a person could learn to control or increase his or her skin temperature when given verbal instruction and a feedback signal that were matched to their primary learning system.

The question of matching a person's primary learning system to the kind of biofeedback signal and instruction received has not been addressed by other researchers. Based on the observation that people learn and think differently from each other, and that these individuals may possess a primary strength in learning, it is reasonable to ask if the process of learning biofeedback can be enhanced under these conditions.

This research may provide an easier and more effective way in which people can learn biofeedback. It may also answer some of the questions concerning the fact that some clients cannot learn or benefit from biofeedback at all. Benefits may also be received by people who have already enjoyed a successful biofeedback experience, one of which may be a shorter training period. Since biofeedback has become an important component of treatment in many areas, a faster and more efficient method of learning biofeedback has important implications both to an individual receiving the training and to the person administering the training.
Chapter 2

LITERATURE REVIEW

Early History of Biofeedback

Biofeedback is a relatively young field of research. Most of this research began in the late 1960's, when an atmosphere or climate existed which emphasized and encouraged individual self-exploration, self-discovery, and self-control of physiological functions. Since biofeedback demonstrates an individual's capacity for self-control and creates confidence that such a thing is possible, biofeedback research was a natural outgrowth of the 1960's emphasis on the self and the possibility of enhancing human potential.

In the late 1960's, research being conducted in four separate areas appears to have stimulated the birth of biofeedback and biofeedback techniques. These areas of research were: the studies of operant conditioning of human heart rate and of galvanic skin response, studies with curarized animals, and studies on the control of alpha brain waves.

A part of this research was encouraged by Kimble's (1961) statement that autonomically mediated behavior or responses could be modified by classical, but not instrumental, training methods. Instrumental or operant conditioning refers to a type of learning in which behaviors
that already exist in an organism’s repertoire are strengthened or weakened through the use of rewards and punishments; the administration of rewards and punishments is contingent on the organism’s responses. In other words, a response or a behavior can be increased with positive reinforcement or positive feedback and decreased with negative reinforcement or negative feedback. This is in contrast to the classical conditioning paradigm in which stimuli are paired irrespective of the organism’s response. Thus Kimble proposed that responses that were thought to be "involuntary" and under the control of or innervated by the autonomic system, such as stomach acid and secretion, heart rate, skin resistance and blood pressure, could not be influenced by instrumental or operant conditioning. Instrumental learning was thought to effect responses which were under "voluntary" control such as skeletal muscle responses, etc.

Soon researchers began to test Kimble’s assumption and studies began to show that autonomically mediated responses could be modified by instrumental conditioning methods. Two such researchers were Shearn (1962) and Frazier (1966), who demonstrated that heart rate could be increased or decreased when using a shock avoidance research technique. Later studies showed that heart rate could be operantly conditioned by using positive reinforcement instead of the negative reinforcement required in the shock avoidance technique.
A second avenue of research which dealt with galvanic skin response (GSR) was being conducted by Kimmel (1974; 1967). These studies along with the work of Greene (1976) showed that galvanic skin response could be operantly conditioned. However, while research in other areas continued, research with galvanic skin response diminished. This may have been due in part to the lack of an application of GSR techniques to the clinical setting.

The third avenue of research concerns the work of Miller, DiCara and their associates. It must be noted that these researchers were also influenced by Kimble’s (1961) assertion that autonomically mediated behavior could be modified by classical but not instrumental training methods. The work of Miller, DiCara and associates is often cited in reference to the field of biofeedback. Miller (1969) tested Kimble’s assertion by using animals, mainly curarized rats. Miller set out to prove that autonomic responses could be instrumentally conditioned. In order to accomplish this, Miller had to eliminate or rule out any other possible explanation for the results that were obtained. Much of the early criticism of the work on operant conditioning of autonomic responses was

based on the fact that some voluntarily controlled responses can elicit an "involuntary" or autonomic response. Given that fact, critics argued that what was being conditioned were voluntary responses which elicited the autonomic response rather than directly conditioning the autonomic response itself (1978, Blanchard & Epstein, p. 7).

For example, changes in heart rate can be brought
about or affected by changing breathing rate (i.e. fast or slow, deep or shallow) or by tensing certain skeletal muscles. These two responses, alteration of breathing patterns and tensing of muscles are under voluntary control. This meant that if changes in heart rate, an autonomically mediated response, were "caused" by changes in responses under voluntary control, heart rate could not be proven to be instrumentally conditioned.

In order to avoid the question of some autonomic responses being affected by voluntary control, Miller devised the following research method: laboratory animals were injected with curare, a drug which paralyzes all skeletal muscles, even those that would enable animals to breathe. Curare was used because it blocks the motor end plate of skeletal muscles (myoneural synapse). These animals were also maintained on artificial respiration, which regulated their breathing and kept them alive. In addition, an electrode was implanted in one of the "reward centers" or "pleasure centers" of the hypothalamus, in order to give reinforcement to the paralyzed animal. Olds (cited in Blanchard & Epstein, 1978, p. 7) had previously shown that mild electrical stimulation of these areas could serve as reinforcement.

By using this research technique, Miller, DiCara and their associates (1968, Miller & DiCara; 1967, Trowhill; 1969, Miller) showed that heart rate could be operantly controlled. In addition, they also proceeded to show that
blood pressure, urine formation (1968, Miller & DiCara; 1967, Miller & Dicara) and both vasoconstriction and vasodilation in an animal's ear (1968, DiCara & Miller) could be operantly conditioned.

With this series of experiments Miller was able to demonstrate that visceral learning could be influenced or changed by operant conditioning. The magnitude of the change in visceral responses that had been demonstrated by this research encouraged other biofeedback researchers and workers to speculate on human psychosomatic disorders that might be treatable by biofeedback methods. It is a matter of note that the early animal research aided and supported the field of human biofeedback in its very early days, when such support was needed. Since little clinical application of biofeedback was in progress in 1969, animal research (1979, Blanchard & Epstein, p. 5-9) did much to encourage a variety of human clinical applications.

Despite the importance of Miller's findings of the effect of operant conditioning on autonomic responses, problems began to emerge with regard to replication of Miller's experiments (1974, Miller & Dworkin; 1978, Miller). Replication seemed promising in the beginning, even with non-curarized human subjects (1969, Shapiro, Tursky, Gersheon & Stern) but with the increasing passage of time, the results of the animal studies began to show a decline in the confirmation rate. Eventually Miller himself was not able to replicate his earlier results in his own laboratory.
Although these early animal studies were a necessary impetus to the development of biofeedback research, human biofeedback research has developed its own special place, by demonstrating its usefulness with increasing success in clinical settings. Researchers such as Budzynski, Stoyva, Adler & Mullaney (1973), Haynes, Griffen, Mooney & Parise (1975) and Phillips (1978) had demonstrated biofeedback to be effective in the treatment of tension headache. Basmajian (1963a, 1963b, 1978), had demonstrated that fine control of muscles could be accomplished by use of electromyographic (EMG) biofeedback training. This finding has had important implications for the field of neuromuscular reeducation. In addition, biofeedback for treatment of cardiovascular disorders, particularly essential hypertension has become a major component of treatment for this disorder (1971, Benson, Shapiro, Tursky & Schwartz; 1975, Kristt & Engel; 1977, Friedman & Taub). Thus, clinical biofeedback as it applies to humans had demonstrated its clinical usefulness.

The last avenue of research which led to the field of biofeedback was work with EEG. Kamiya (1962) had begun to study whether subjects could voluntarily produce certain EEG patterns, specifically the alpha rhythm. Kamiya discovered that individuals who received correct feedback could identify whether or not they were in state A (alpha rhythm, a pattern of 8-13 Hz, cycles per second) or state B (beta rhythm, a pattern of 13-40 Hz, cycles per second),
which is a faster brain rhythm. Some individuals became so sensitive, they were correct 100% of the time. Kamiya also demonstrated that individuals could switch back and forth between alpha and beta brain waves upon command. Thus Kamiya (1969, 1968) had demonstrated that individuals could produce different brain wave patterns at will. Another researcher, Dr. Barbara Brown has demonstrated feedback control of brain waves during her studies with lights and brain waves. Her equipment was designed so that a special color light would appear each time a subject was in a particular brain wave pattern. Brown's (1970, 1971) subjects were able to discover how to operate the lights and how to change their internal states to control brain waves by using feedback about their internal experience to alter brain wave patterns. Because the subjective experience of a "high alpha state" was similar to that reported in meditation, the studies of working with self control of EEG became very popular with the general population and thus helped the field to grow. During this time the popularity and acceptance of Eastern religions, along with such things as meditation, hypnosis, yoga and relaxation, helped the general public to focus on new possibilities of self growth that involved the mind and altered states of consciousness (1986, Norris; 1985, Roberts).

Since researchers involved in this EEG work resided in California, they came to know each other. They started an informal network of communication which was organized by
Dr. Brown. They eventually met as a group in October of 1969 and from this meeting of 140 persons emerged a new organization which was called the Bio-Feedback Research Society. The term biofeedback came into general use at this time.

Annual meetings of the Bio-Feedback Research Society were held and the membership continued to grow. By 1977 the society had over 1000 members and began to publish its own journal which was called Biofeedback and Self-Regulation. In 1976 the name of the society was changed to the Biofeedback Society of America in order to accommodate the increasing numbers of practitioners of clinical biofeedback, as well as those interested in research. In 1989 the name was again changed to the Association for Applied Psychophysiology and Biofeedback.

Biofeedback as a clinical practice has become a widely accepted form of treatment for many disorders. Although biofeedback is only about fifteen years old, many books, experimental studies and much popular literature are available. Roberts (1985) concludes that biofeedback has been demonstrated to be an effective therapeutic tool when used with other techniques, even though the theoretical explanation once provided by Miller is not clearly supported by current research. Miller (1978) also concludes that the use of clinical applications is effective. Miller contends that some of the research has successfully shown its effectiveness. Other researchers (1986, Schellenberger & Green)
have started to examine research methods in order to establish more effective results. From actual clinical use and from some of these previously cited studies, it appears that when individuals are given feedback about some of their body's functions, they can learn to control their body functioning to some degree. An explanation of why this occurs has been proven to be elusive and this is not all together unreasonable when one considers the complexity and the intricacy of the psychological and physiological processes of the human body.
Modality Concept

As early as the eighteenth century such men as Rousseau argued that sensory experience was the basis for all knowledge. Rousseau also claimed that it was important to be aware of the characteristics of an individual and gave much emphasis to the process of how a person learns. The work of Pereira (1976, Kramer), Condillac (1976, Lane), Froebel (1976, Kramer) further developed the concept that children displayed a great deal of variety in their sensory characteristics and that a specialized program of individualized instruction could benefit both disabled and normal children greatly. The well publicized work of Itard (1976, Lane) with the "enfant sauvage" reveals that Itard advocated personal instruction with attention to the intellectual differences of each individual as well as attention and reliance upon the sensory or modality strengths. Charcot, in 1886, acknowledged that each person has a particular modality of choice in learning, a typology of "visile", "audile", and "tactile" learners (1977, Wepman). Finally and more recently, Maria Montessori (1976, Kramer) pioneered specific techniques based on Itard’s important idea of educating the senses by working through modality strength and only then being concerned with dispensing educational information.
Through research and philosophical thought as described above, an axiom was developed in the field of psychology and other related fields, that man's experience of his world is dependent on the input of his sensory modalities. The sensory modalities are the only pathways by which phenomena occurring outside the brain of the individual are conveyed to the individual (1979a, Swassing & Barbe; 1976, Bandler & Grindler; 1977, Bandler & Grindler; 1977, Dilts). Modalities may be described as the channels through which people receive information. The generally accepted sensory channels are the auditory, visual, kinaesthetic, olfactory and gustatory. Of these five sensory channels, our culture emphasizes the importance of auditory, visual and kinaesthetic modalities as the most important sources of information. Each of these modalities processes different stimuli to make discrete factual distinctions about those stimuli. Information from any one of these modalities, or from any combination of modalities, may elicit responses or behaviors chosen by the individual to initiate. Thus a sensation occurs when an object or energy source from the environment impinges on an individual (1979a, Swassing & Barbe). For example, the sound of an animal or a flash of light will generate sensations. When meaning is derived from or attributed to sensation, an individual steps into the realm of perception (1967, Epstein). When this occurs, an individual's past experiences can be
called upon to relate the sensation to a previously occurring event.

A major component of the definition of perception is the existence of memory. If meaning is to be given to sensation, one must have relevant information stored in some particular place. This storehouse or place is memory.

Most psychologists agree that memory consists of at least two components, one of which deals with information on a short term basis and another that retains information for a longer time. In addition, Miller (1956) has established that the conscious mind can be aware of a maximum of 7 ± 2 chunks of information at any one time. These chunks are discrete units of information. An individual may consolidate units of information so as to have more consciousness available for additional material, but the maximum of nine discrete chunks can never be exceeded. An example of this would be to examine the number series 2, 4, 6, 8, 10, 12, 14, 16, 18: that series contains nine discrete facts. If it is consolidated to the even numbers between 2 and 20, it becomes one chunk of information. Then the conscious mind can be aware of additional information.

As was previously mentioned, the two kinds of memory an individual can possess are short term and long term memory. Short Term Memory (STM) has a limited storage capacity (5-9 items) and a short duration. Items stored in STM are quickly forgotten if they are not transferred to long term memory. For example, an individual may have just looked at
a number in a phone directory, and if he or she is
distracted or made a mistake in dialing, the odds are that
this person will have to look up this number once again.
Long term memory (LTM) is often called "permanent" memory
that has a seemingly unlimited capacity. LTM endures for
very long periods of time, if not for the life of an
individual.

Memory, sensation, and perception are all closely
related phenomena. Sensation underlies both memory and
perception. Without reception of stimuli from the environ-
ment, neither perception or memory could function. An
individual's senses provide the information or raw material
that is utilized by perception and memory. The individual
must selectively search the available stimuli or raw mate-
rial for those stimuli that have significant relevance. In
the searching task, some sensations will be ignored, while
other sensations receive attention. One of the ways an
individual can "process" these sensations is to rely on an
internal representation of experience. Since a modality may
be described as any of the sensory channels through which an
individual receives and retains information, each individual
may use some sensory channel more so than another (1979a,
Swassing & Barbe). Each individual has his or her own level
of modality functioning. Some people are more efficient in
making fine discriminations among visual stimuli; some make
comparatively finer discriminations among auditory stimuli;
others may be most efficient at interpreting kinesthetic
stimuli. Some researchers believe that modality may be a physiological characteristic with which an individual is endowed and that hereditary factors chiefly determine modality strength (1971, Wepman). Thus a child who strongly prefers the auditory pathway becomes an adult who will prefer his or her auditory modality. Such a person will be an auditory learner for the rest of his or her life. Wepman reached the conclusion that each child has a definite propensity for using one sensory input channel rather than others. On the other hand, Swassing & Barbe acknowledge that perception and memory are links of a chain between a sensation and the individual’s resultant behavior and define modality strength operationally as the ability of an individual to perform an academically relevant task in each of the major modalities (1979a, Swassing & Barbe, p. 5). They maintain that both heredity factors and the environment may be important factors in determining an individual’s modality strengths (1979a, Swassing & Barbe, p. 5). Swassing & Barbe also acknowledge that modality preference does exist but state one qualification for this, which is, that the manner in which a person is most comfortable in receiving information may not always be the way in which information is most efficiently received and processed. In order to measure modality these researchers equate modality strength with functioning in each modality and not modality preference. Another concern with modality preference is that it is usually an individually subjective assessment and,
therefore, not reliable or capable of being accurately measured.

Thus the possibility exists that learning could be enhanced if modality strength is utilized. A person might take in more information, when it is given in a way that encourages use of an individual’s strongest modality function.
The Current Research

This research study wishes to examine if the learning of biofeedback responses can be improved by utilizing an individual’s preferred learning style rather than offering biofeedback training that does not utilize an individual’s preferred learning style. Individuals may learn in different ways or process information more effectively by using a particular sensory mode or modality. Making use of a person’s primary modality by incorporating this idea into the teaching techniques involved in a biofeedback session might improve the effectiveness of biofeedback training. This research will first identify each individual’s primary learning style or modality by testing them individually and then provide for either matching or mismatching feedback modalities in order to see how the learning of biofeedback responses was affected. Subjects will receive an individual biofeedback training session to see if they can achieve a significant increase in skin temperature when they have received teaching instructions that enhance their primary learning modality or when such is not the case.

The type of biofeedback used in this study will be fingertip skin temperature. Body temperature is affected or controlled by the circulation of the blood. When blood is
flowing through the vessels freely, vasodilation is occurring and blood vessels increase in size and allow greater blood flow, which is followed by higher skin temperatures. On the other hand, when blood vessels constrict or tighten-up, vasoconstriction is occurring and blood vessels decrease in size and restrict blood flow, which is followed by lower skin temperature. When this happens, certain parts of the body, particularly the extremities, may feel cold. Vasoconstriction may cause cold hands, cold feet and can also reduce body temperature. It is believed that warm hands and feet indicate a relatively good blood flow and, therefore, it is worthwhile to teach individuals to attain this goal (1981, Danskin & Crow; 1981, Brown; 1980, Olton & Noonberg). That normal subjects have the ability to raise and lower their fingertip temperature has been established by several research studies (1975, Keefe; 1973; Roberts, Kewman & McDonald; 1976, Taub & Emurian).

The technique of thermal skin temperature biofeedback has received much research attention. During the early seventies, Machac, Volow & Hein and Stern & Pavloski (cited in Brown, 1981, p. 160) initially demonstrated that learned control of blood vessel activity was possible and that individuals could learn to control their fingertip temperature. Such control of autonomic activity was a fairly recent discovery. Thus research on the application of biofeedback for control of vascular function was underway. Since then, skin temperature biofeedback has
enjoyed a number of effective clinical applications. In the early seventies, Elmer and Alyce Green were conducting research with biofeedback and Autogenic Training. They noticed (1977, Green & Green; 1970, Green, Green & Walters) an increase in a client’s fingertip skin temperature when a client reported that a headache had gone away. This had important implications for the treatment of migraine headaches. Since then, skin temperature biofeedback has become an important component of treatment for migraine as well as tension headaches (1978, Blanchard & Theobold; 1976, Shapiro & Surwit; 1973, Sargent, Walters & Green). Another example of the effectiveness of skin temperature biofeedback is in the treatment of Raynaud’s disease (1973, Jacobson, Hackett, Surman & Silverberg; 1973, Surwit; 1975, Blanchard & Haynes). Individuals who suffer from this disease have a chronic problem with cold hands and cold feet and even relatively minor events, such as removing a milk carton from a refrigerator, may cause the hands to become cold, white, insensitive to touch and difficult to move. Such an event will produce an attack that will last for several hours. Biofeedback treatment techniques for this group of individuals offers a possible means of alleviating an attack through teaching clients to increase their hand temperature.

Thus thermal biofeedback control has been shown to be effective in a number of research studies and through actual clinical application. Many of these studies mention that clients differ in their ability to achieve voluntary
control of fingertip temperature. Some subjects are able
to increase temperature and exhibit a high degree of vol-
untary control over the processes involved in raising skin
temperature. In biofeedback research a number of individual
differences have been noted. Roberts (1985) noted that one
such difference is that individuals appear to differ in
their ability to learn. That people may learn in different
ways might be considered to be an important component of a
technique such as biofeedback, in which much depends upon a
person's ability to process teaching instructions and then
utilize this information to increase skin temperature.
Individual learning differences could also be considered to
be one of the non-specific factors (1987, Pepper & Sandler;
1976, Meichenbaum) that a clinician might use to optimize
the learning of biofeedback responses in the clinical
setting. Non-specific factors are aspects that might occur
beyond and outside of actual biofeedback training.
Meichenbaum suggests that a client's thoughts, images, and
feelings that precede or accompany the physiological
response in biofeedback training deserve more attention.
Taking into account a client's cognitions, specifically
thoughts and images, and incorporating these factors into
the training procedure might be beneficial to the client and
increase the possibility of a successful biofeedback experi-
ence. It might help a client to be more receptive to the
new training situation. One way of doing this would be to
use an individual's learning style or primary modality as a
way to tap into a client’s way of thinking, thereby assessing the way he or she processes information.

Utilization of individual primary learning modality requires the use of a test or method to assess their particular learning style. Ways to measure learning modality have been available since the 1800’s (1979a, Swassing & Barbe). Although there are many tests on the market that claim to assess learning modality, some have limitations that make their use undesirable. It was not until after the 1960’s that such tests as the Illinois Test of Psycholinguistic Abilities (ITPA) came into use. The ITPA assesses visual and auditory processing and retention but requires extensive training before it can be properly administered.

Another instrument, The Learning Methods Test, was the first assessment procedure that measured or tapped all three modalities and their combinations. This test also has several limitations, as it is very time consuming and only appropriate for very young children.

In addition, another assessment in use is the frequently used, Learning Style Inventory, which is a self-report instrument consisting of 104 true-false items. Questions are answered as they reflect an individual’s personal style. Since this test relies on perceived strengths as determined by self-reporting, it is likely that the Learning Style Inventory measures modality preference and not modality functioning or strength. Also, in order
for modality to be valid, an instrument should not rely on subjective assessment.

Such assessment and administration problems as mentioned in discussion of the ITPA, the Learning Methods Test and the Learning Style Inventory, indicated the need for a better instrument with which to assess learning modality. Waugh (1973) and Newcomer & Goodman (1975) both pointed to the need to develop a reliable way to measure learning modality functioning. Both of these researchers were unable to demonstrate increased learning through instruction offered in a child's primary modality and pointed to the testing instruments available as a major part of the problem. The methodological problems associated with the previously mentioned studies of Waugh and Newcomer & Goodman, specifically identifying an individual's learning modality, led to the development of the Swassing & Barbe Modality Index (SBMI). The SBMI attempts to provide an instrument that has a short administration time, does not require extensive training to administer, measures modality strengths rather than deficits, presents the same stimuli to an individual that is consistent for each of the three modalities and does not require that an individual be able to read (1979a, Swassing & Barbe, p. 35). The SBMI has been standardized and the instrument has application both in the classroom and in research settings (1988, Miller; 1980, Bradbury). Although Bradbury did not find a relationship between an individual subject's dominant modality system and
his/her comprehension of information, she cited the lack of a sophisticated instrument for measurement of communications as a problem and not the Swassing-Barbe Modality instrument.

This study will be concerned with subjects who have an auditory or visual primary learning modality. Because each person is continually exposed to incoming information, which is received through the sense systems of sight and hearing, it appears necessary to organize this incoming stimuli in some fashion (1976, Bandler & Grindler). If a visual modality person processes information by creating or recalling images or pictures internally, then instructions which contain words that correspond to a visual modality processing system would be most beneficial for quick, efficient processing to take place. Similarly, a person who possesses an auditory modality processes information by creating or recalling sounds, dialogues or conversations, would benefit from receiving instructions that contain words that correspond to an auditory modality. Such words or modality referents that pertain to an auditory or visual modality will be provided for subjects in this study (See Appendix A for list of modality referents). Modality referents might be used to tap into the way an individual represents and organizes his or her internal reality. If this does occur, use of modality referents might facilitate the learning process thereby enhancing the processing of new information. Although the matching of language to a
person's primary modality appears logical, there is no research evidence to substantiate this conclusion.

This study will incorporate a person's primary learning modality and a biofeedback procedure in order to determine whether or not subjects in matched or mismatched treatment conditions will be able to increase their skin temperature. The implications or research findings generated from this study may result in improved biofeedback teaching techniques or training.
The central concern of this experimental study has been the relative efficacy of two approaches to learning biofeedback. Biofeedback instruments provide for either an audio or visual feedback signal. Individuals may possess a primary learning modality, which may be either audio, visual or kinesthetic. This study examined whether or not biofeedback learning is more efficiently accomplished when the feedback equipment signal and the researcher’s instructions are matched to the individual’s primary system or when such is not the case.

The scope of this study is limited to investigation of learning voluntary control of body temperature via the auditory and visual modalities. Because biofeedback equipment does not provide a kinesthetic signal, kinesthetic subjects were not a part of this research study.

Operational Definitions
A. MODALITY - Any of the sensory channels through which an individual receives and retains information.
B. VISUAL MODALITY - The visual modality processes stimuli presented by the examiner to the individual’s sight.
C. AUDITORY MODALITY - The auditory modality processes sounds articulated by the examiner for the individual’s hearing.

D. KINESTHETIC MODALITY - The kinesthetic modality processes stimuli obtained by the individual, with the eyes closed, feeling or touching three dimensional shapes with his/her hand; the shapes that have been presented by the examiner.

E. MODALITY REFERENTS - Process words are verbs, adjectives and adverbs, that individuals use to reflect their particular thinking style or use to describe their internal experience. However, each modality tends to use specific process words to describe its experience. Therefore visual, auditory and kinesthetic process words may be used by an individual with a corresponding visual, auditory or kinesthetic learning modality (see Appendix A for lists of modality referents).

F. THERAPIST FEEDBACK MODE - Words (modality referents) chosen by the therapist which are reflective of the three modalities (i.e visual, auditory or kinesthetic).

G. BASELINE TEMPERATURE - An averaged temperature, based on one minute readings, which were recorded for a period of five minutes.

H. CHANGE SCORE - The difference between an individual’s baseline skin temperature and skin temperature at the end of a biofeedback training session.
Hypotheses

The general research hypothesis investigated whether or not giving feedback signals that matched or mismatched primary learning modality would enhance the learning of biofeedback.

This idea was tested by the following five null hypotheses:

**Ho1:** Within audios, there is no difference in change of skin temperature, between those receiving similar and dissimilar feedback signals.

**Ho2:** Within visuals, there is no difference in change of skin temperature between those receiving similar and dissimilar feedback signals.

**Ho3:** Across all subjects there is no difference in the amount of skin temperature change by those receiving similar and dissimilar feedback information.

**Ho4:** There will be no difference in the amount of skin temperature change by subjects with low, medium or high baseline temperatures.

**Ho5:** There will be no interaction effect of baseline temperature and similarity of feedback response on change of skin temperature.
Sample

The sample group consisted of 60 adults, all of whom were volunteers. Subjects were recruited from the general population and also consisted of undergraduate students at California State University, Hayward. All subjects were eighteen years of age or older and possessed a visual or auditory learning modality.

Participants were required to be free of any vision or auditory problems that would interfere with their learning during a biofeedback training session. Also, individuals who had previously experienced biofeedback training, were not allowed to participate in the study. Subjects taking stimulants or possessing a major medical problem, for which they were currently taking a prescription drug, were also excluded. The modalities of subjects and their assignment to treatment groups are shown in Figure 1.

Instruments

The section will contain a description of the instruments used in this study. The following instruments were used for the purposes of assessing modality and for biofeedback training.

Swassing Barbe Modality Index (SBMI) (Zaner-Bloser, 1979): This instrument was designed to measure the within self relative functioning of the three major sensory
<table>
<thead>
<tr>
<th>SUBJECTS</th>
<th>METHOD OF FEEDBACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBMI</td>
<td>BIOFEEDBACK SIGNAL AND VERBAL INSTRUCTION</td>
</tr>
</tbody>
</table>

Figure 1. Distribution of subjects and conditions.
modalities, visual, auditory, and kinesthetic. The test
designers define the dominant modality as the channel through
which information is processed most efficiently.

The design of this test (SBMI) is a matching-to-
sample task: the stimulus is presented and the subject
duplicates the stimulus. The stimulus items are three
dimensional shapes (circle, square, triangle and heart)
presented in varying sequences and combinations. The
sequences, displayed on nine plastic strips for ease of
presentation, range from one shape to a complex sequence of
nine shapes. The subject has a number of matching shapes
available and arranges a sequence from these that is to
duplicate the stimulus sequence after the stimulus is
removed.

The test takes approximately twenty minutes for
administration. The examiner stops testing in any section
when the subject makes an error in duplicating two consec-
utive sequences or responds to all stimulus sequences. In
the development and subsequent standardization of their test,
Swassing and Barbe found no indication of a learning effect
from having the same series of stimulus sequences presented
three consecutive times.

Scoring consists of one point for every correct
choice of placement. All sections (auditory, visual and
kinesthetic) are totaled and then each section score is
converted into a percentage. An example of how scoring is
done is as follows:
EXAMPLE: Subject Jones had a total score of 61 correct choices.

Visual score correct choices = 35/61 = 57%
Auditory score correct choices = 16/61 = 26%
Kinesthetic score correct choices = 10/61 = 16%

Ranking of modality functioning for S-10:
1. Visual
2. Auditory
3. Kinesthetic

This conversion to percentages gives an immediate within self ranking as to the individual's modality functioning. According to Swassing and Barbe, five percentage points or more difference between scores of modalities is an educationally relevant difference. Since a five percentage point difference was considered significant to effect learning, a five percentage point difference was used to determine primary and/or integration of functioning in these results. An individual whose highest score was five points or more apart, from the next highest scoring modality was assigned as having either a visual, auditory or kinesthetic modality. Scores less than five percentage points different were considered to indicate integrated modality functioning with no ranking of functioning. Any person who scored as having an integrated modality function was eliminated as a subject. Standardization of the SBMI (1979, Zaner-Bloser) was based upon 637 students, kindergarten through sixth grade.

In terms of construct validity, a factor analysis of
the raw scores showed consistent grouping of three factors corresponding to the visual, auditory and kinesthetic modalities. A measure of indirect validity was conducted by comparing achievement scores, measured by the Comprehensive Test of Basic Skills (1979a, Swassing & Barbe, p. 50), with the modality scores. The resulting factor analysis showed achievement scores were not related to modality scores.

Test-retest reliability, conducted at a four month interval, showed reliability coefficients of .61 for the visual subtest, .65 for the auditory subtest and .67 for the kinesthetic subtest. The coefficients of reproducibility for the subtests on the Gutman scale were all above .90.

Thermal Biofeedback Instrument: The skin temperature biofeedback instrument used is manufactured by the Cyborg Corporation as a P642. This instrument detects minute changes in surface skin temperature, reflecting blood flow to the extremities, and provides the client and the therapist with immediate information on directional changes of finger tip temperature. The client is connected to the instrument by a tiny temperature probe (thermistor), taped comfortably to a finger. The instrument offers visual feedback through digital readouts. Visual temperature is simultaneously displayed by either (Fahrenheit or Celsius scales), both being lighted for readability and use in dark rooms. Auditory feedback is presented in a choice of two modes, (1) pulsed tone which reflects directional change with varying pitch, falling as temperature rises (relaxation) and rising as temperature falls (arousal), and (2) a continuous
tone which moves up and down in a continuing manner. The volume in both modes can be adjusted to comfortable levels.

Procedure

The researcher met individually with each subject to explain the study. Subjects were required to read and sign a consent form. If a subject possessed no major medical, hearing or vision problems and was not taking medication or stimulants, the subject was invited to participate in the study. All subjects were tested in a quiet place where interruption would be unlikely.

The subjects then received the following instructions:

This study deals with the way people process information. Most of us tend to use one system, either auditory, visual or kinesthetic, and this is called our primary learning system or modality. Our first activity is designed to provide information about your primary learning modality and will consist of assembling patterns of shapes which are squares, circles, hearts and triangles. I will present you with a pattern, and you will be allowed to study it for ten seconds (or fifteen seconds depending on the task). I will then ask you to duplicate the pattern with the shapes in front of you. This sequence of activities will be followed for each of the three modalities. Please relax, as there are no right or wrong answers, and this activity will merely
reflect the system that you use most frequently. If you have any questions at this time, I will be glad to answer them.

The subjects were then tested by using the Swassing-Barbe Modality Index (SBMI) to determine their primary learning modality. The test results were then scored immediately and the participants were judged to have an auditory or visual primary learning modality.

Once the modality testing phase had been completed, the subjects were randomly assigned to their biofeedback treatment condition, either matched or mismatched. After the subjects had received their treatment condition, the researcher proceeded to offer an explanation of biofeedback and biofeedback training, along with a demonstration of the biofeedback signal the subject would be receiving. The subject was told:

Now that you have completed the first activity, we will start the biofeedback phase of the study. As you may know, biofeedback is a procedure that offers a person information about an individual's biological functions. The word biofeedback stands for bio (body) and feedback (information). For example, whenever you have a fever and put a thermometer in your mouth, the thermometer reading (the biological feedback) tells you something about what is going on with you. The thermometer does nothing to you, it only gives you information about yourself and acts as an internal mirror for an
internal state. A biofeedback instrument acts in much the same way as a thermometer and provides a person with information about a given internal state or a body process. For the purpose of this study, the biofeedback instrument will be providing you with information about your skin temperature. We are interested in seeing whether or not the manner in which this information is fed back to you is related to your ability to modify body temperature.

Before continuing with biofeedback training, I would like to explain how the biofeedback instrument works. As you can see, the machine is plugged into an electrical outlet and needs electrical power to operate. This electrical power is necessary for the digital display which will inform you of your actual skin temperature (points to display) and for the tone (tone turned up and down), which are feedback signals. These two signals reflect any change in a person's skin temperature. As your skin temperature changes the display will change and the pitch of the tone will also reflect any increase or decrease in skin temperature. Although electrical power is used in the operation of this instrument, it does not reach you in any way and your only connection to the instrument is by way of a sensor attached to your index finger.

This completed the explanation of biofeedback and biofeedback training. If the subject needed further
explanation or had any questions, the researcher proceeded to attend to these aspects.

Baseline Procedure

Upon completion of the explanation of biofeedback and biofeedback training, the researcher provided instruction as to the procedure involved in obtaining a baseline temperature reading. The subject received the following instructions:

As a first step in biofeedback training, it is necessary to take a baseline reading to determine your typical body temperature and this is done by connecting a thermal sensor to your index finger. This is what it looks like. I will also be using some tape to make sure it stays in place. If you like, I can attach it to my finger and give you a demonstration or answer any questions that you may have.

If you are ready to proceed, let me attach the sensor to your finger (sensor will be attached). Because the sensor is attached on the palm side of your finger, I would like you to find a comfortable resting place for your hand, making sure the palm side remains in an upward position (demonstration). Most people find either placing it on the table or their lap to be most comfortable. We will now take a baseline reading of your skin temperature. I will be turning the biofeedback instrument away from you while I take this reading, so that you will not be
influenced in any way. I will let you know what the reading is, in just a few minutes, when it becomes stable enough for us to proceed. For now, do not be concerned about your skin temperature and just let your mind dwell on whatever interests you.

With those instructions given, the researcher proceeded to take a baseline reading for a period of five minutes. After completion of this part of the activity, the subject was given additional information about the twenty minute biofeedback training session. These instructions were verbally loaded (see Appendix B for auditory and visual instructions) with either auditory or visual modality referents (See Appendix A for modality referents).

The instructions for subjects in conditions 2 and 3 used visual terms related to the visual modality, and these subjects also received a visual biofeedback signal. Subjects in conditions 1 and 4 received instructions that contained auditory terms related to the auditory modality and these subjects also received an auditory biofeedback signal.

Subjects in the visual condition, had constant access to their actual skin temperature readings (Fahrenheit), by means of a digital display. Auditory subjects were given their actual skin temperature readings (Fahrenheit), by the researcher, at three minute intervals. Subjects were told when the training session was ending approximately three minutes before the session was completed. At the end of the session, participants were allowed to stretch or to stand, if
Figure 2. Categories for analysis.
Tested
B.F. Signal + Researcher Instruction

<table>
<thead>
<tr>
<th>Baseline Temperature</th>
<th>Similar</th>
<th>Dissimilar</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>T1S1</td>
<td>T1S2</td>
</tr>
<tr>
<td>Medium</td>
<td>T2S1</td>
<td>T2S2</td>
</tr>
<tr>
<td>Low</td>
<td>T3S1</td>
<td>T3S2</td>
</tr>
</tbody>
</table>

Figure 3. Categories for baseline temperature analysis.
they so desired. A discussion of their biofeedback experience followed, as well as a discussion of their scores on the Swassing-Barbe Modality Index. Subjects were also given a handout (See Appendix C) that described characteristics of individuals possessing an auditory, visual or kinesthetic primary learning modality (1979b, Swassing-Barbe Modality Index, Manual).

**Data Analysis**

Previously stated hypotheses were analyzed by analysis of variance as indicated by grouping of individuals as shown in Figures 2 and 3.

In order to obtain a stable temperature reading for each individual, a baseline temperature score was obtained during the first five minutes. This temperature reading was compared to an individual's temperature at the end of the biofeedback training session. The difference between these two temperature readings reflected the change score, up or down. All data analysis utilized individual change scores.
Chapter 4

RESULTS AND DISCUSSION

Introduction

The information presented in this chapter will deal with the evaluation and interpretation of the findings of this research study. Five research hypotheses were tested. Hypotheses 1 and 2 examined whether subjects in a similar or matched treatment group could learn to raise their skin temperature more readily than subjects in a dissimilar or mismatched treatment group. Subjects in the visual similar or matched group received researcher instruction and biofeedback signal, which were matched to their primary learning modality. Hypotheses 3, 4 and 5 were developed to test the possible impact of baseline temperature on change score temperatures of all matched and mismatched subjects.

The information in this chapter will be presented in the following manner. Each hypothesis will be stated and discussion of the results will immediately follow the hypothesis statement. Tables pertinent to each individual hypothesis will also appear in the discussion section. The four tables included in this chapter will include the statistical data for each hypothesis.
Statistical Analysis

Hypotheses 1-5 were tested in the null form as shown below.

H₀₁: Within audios, there is no difference in change of skin temperature between those receiving similar and dissimilar feedback signals.

A one-way analysis of variance performed on change score data indicated that change in skin temperature did not significantly differ between the auditory group matched on primary modality and the auditory group that was mismatched on primary modality. The results for the auditory group were $F = .68, p > .05$. The mean increase in temperature for the similar auditory group was 3.17 degrees F and the dissimilar treatment group had a mean of 4.35 degrees F (See Table 1). It was expected that auditory subjects receiving researcher instruction and biofeedback signal that was matched to their primary learning modality would show a greater increase in skin temperature, which would be larger than would auditory subjects who were not matched.

The results obtained were the opposite of what was expected, as subjects in the mismatched group demonstrated higher change temperature scores. However, these auditory subjects in the mismatched group showed considerable variability in their change score temperatures. Five subjects ranged between 1.3-3.9 degrees and two subjects
Table 1

One-way Analysis of Variance for Auditory Data

Means and Standard Deviations for Dependent Variable

<table>
<thead>
<tr>
<th>Treat</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.17</td>
<td>2.1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>4.35</td>
<td>3.22</td>
<td>8</td>
</tr>
</tbody>
</table>

Completely Randomized Analysis of Variance Performed on Dependent Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Sums of Squares</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat</td>
<td>5.19</td>
<td>1</td>
</tr>
<tr>
<td>Error</td>
<td>98.95</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat</td>
<td>5.19</td>
<td>.68</td>
</tr>
<tr>
<td>Error</td>
<td>7.61</td>
<td></td>
</tr>
</tbody>
</table>
exhibited change scores of 8.6 and 10.7. Since this auditory group was small and had only eight subjects, the larger change skin temperature scores of these two subjects may have accounted for these results.

In addition, while change score temperatures for the matched group were relatively stable (0.1-5.0 degrees), modality scores for these auditory subjects in the similar condition were markedly skewed. Five subjects possessed only a five point spread between the two strongest learning modalities, and five points is the minimum difference allowed for ranking of modalities. Most of these subjects had an auditory primary learning modality with visual as their next highest scoring modality, and it might be uncertain as to what learning modality they were actually using. It is quite possible that the subjects were using their visual modality, as well as their auditory modality, in view of each subject’s similar and closely ranked modality scores. In addition, these two modalities may have interfered with each other in processing information. The other two subjects in this treatment condition possessed a twenty-five point spread between modalities. Thus both the matched and mismatched auditory groups had certain factors operating, such as skewed change scores and closely ranked learning modality scores, which could have influenced the observed results.

**H02**: Within visuals, there is no difference in
change of skin temperature between those receiving similar and dissimilar feedback signals.

A one-way analysis of variance performed on change score data indicated that an increase in skin temperature did not significantly differ between the visual treatment groups matched on primary modality and those mismatched on primary modality. The results for the visual group were $F = 1.5, p > .05$. The mean increase in temperature for the similar group was 4.7 degrees F and the mean increase in temperature for the mismatched group was 3.42 degrees F (See Table 2). Change score data did indicate higher skin temperatures for the matched visual group. However, while these temperature increases were in the expected direction, they were not significantly higher. It was expected that visual subjects matched on primary or preferred modality would show an increase in skin temperature significantly larger than those given feedback and instruction in a non-primary modality. Since no significant difference was found when the change score data was analyzed, the indications were that being given biofeedback in a preferred method of learning does not appear to enhance a visual subject's ability to learn to control skin temperature during a skin temperature biofeedback training session.

In addition, it must be noted that 15 out of 24 matched visual subjects started out with a baseline temperature of 87.5 degrees F. Baseline temperatures of 87.5 degrees F indicate a relatively high temperature
### Table 2

One-way Analysis of Variance for Visual Data

#### Means and Standard Deviations for Dependent Variable

<table>
<thead>
<tr>
<th>Treat</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.7</td>
<td>3.54</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>3.42</td>
<td>3.44</td>
<td>21</td>
</tr>
</tbody>
</table>

#### Completely Randomized Analysis of Variance performed on Dependent Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Sums of Squares</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat</td>
<td>18.26</td>
<td>1</td>
</tr>
<tr>
<td>Error</td>
<td>525.08</td>
<td>43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat</td>
<td>18.26</td>
<td>1.5</td>
</tr>
<tr>
<td>Error</td>
<td>12.21</td>
<td></td>
</tr>
</tbody>
</table>
reading for the beginning of a biofeedback training session. Since it becomes difficult to raise skin temperature as one approaches 90 degrees F, a smaller change score would be a natural expectation for subjects in this category. Therefore, baseline temperature may be an important physiological consideration as to why expected results were not obtained.

A 2x3 analysis of variance was performed on hypotheses 3, 4 and 5. These hypotheses investigated the effects of similar and dissimilar conditions and also examined the effect of temperature change in Low, Medium and High levels of baseline temperature. Data pertinent to Hypotheses 3, 4, and 5 are shown in Table 3 and 4.

Ho3: Across all subjects there will be no difference in the amount of skin temperature change by those receiving similar and dissimilar feedback information.

Statistical analysis performed on change score data did reveal significantly different changes for those subjects receiving similar and dissimilar instruction and feedback signal. The results were $F = 14.37, p < .001$. The mean temperature gain for the similar group was 4.35 degrees F, $N = 31$; the mean temperature gain for the dissimilar group was 3.67 degrees F, $N = 29$ (See Table 3).

Thus when all similar subjects were compared with all dissimilar subjects, there was a highly significant finding. From these results, it would appear that all matched subjects regardless of having an auditory or visual learning modality were able to demonstrate higher change
Table 3

Baseline Temperature Data

<table>
<thead>
<tr>
<th>Baseline Temperature</th>
<th>Similar</th>
<th>Dissimilar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>A1B1</td>
<td>A1B2</td>
</tr>
<tr>
<td>91.5°F - 94.0°F</td>
<td>N = 9</td>
<td>N = 11</td>
</tr>
<tr>
<td></td>
<td>$\bar{X} = 2.01$</td>
<td>$\bar{X} = 1.87$</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td>A2B1</td>
<td>A2B2</td>
</tr>
<tr>
<td>87.6°F - 91.0°F</td>
<td>N = 11</td>
<td>N = 9</td>
</tr>
<tr>
<td></td>
<td>$\bar{X} = 4.08$</td>
<td>$\bar{X} = 2.9$</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>A3B1</td>
<td>A3B2</td>
</tr>
<tr>
<td>73.5°F - 87.5°F</td>
<td>N = 11</td>
<td>N = 9</td>
</tr>
<tr>
<td></td>
<td>$\bar{X} = 6.54$</td>
<td>$\bar{X} = 6.66$</td>
</tr>
</tbody>
</table>

N = 31
$\bar{X} = 4.35$
B1

N = 29
$\bar{X} = 3.67$
B2
skin temperature scores. This temperature increase occurred while subjects were receiving researcher instruction and biofeedback signal that were matched to their primary learning modality, according to the SBMI. This finding might suggest that learning modality may affect or enhance a matched subject’s ability to increase skin temperature during a skin temperature biofeedback session. Thus by capitalizing upon a tendency that is present within a subject, namely primary learning modality, it may be possible to use this modality to enable a subject to function more efficiently at a learning task. Skin temperature biofeedback training may be facilitated or enhanced by offering instruction with regard to a client’s preferred learning modality, since temperature increases occurred while subjects utilized a technique which matched their primary learning modality. This appears to offer support to the modality concept. Researchers (1979a, Swassing & Barbe; 1975, Newcomer and Goodman; 1973, Waugh) have also referred to increased learning by matching preferred modality and teaching method in order to enhance or increase the learning of information.

H04: There will be no difference in the amount of skin temperature change by subjects with either low, medium or high baseline temperatures.

Statistical analysis did not reveal a significant difference between subjects who had low, medium and high baseline temperatures. The F ratio obtained in making the comparison in each group was $F = .31$, $p > .05$. The mean
gain in temperature for subjects in the three categories was
High = 1.93 degrees F, Medium = 3.55 degrees F and
Low = 6.59 degrees F respectively (See Table 3).

Although baseline temperature was considered to be a
possible component of any skin temperature increase that a
subject could achieve, no statistical significance as to the
importance of baseline temperature was found. However,
visual inspection of the treatment means reveals a differ-
ence of at least 2 degrees F. Since this was not enough of
a difference for statistical significance to occur, it may
be that the variability within the small groups accounted
for this observed difference. This large variability was
especially evident in the low baseline group, in which the
change scores ranged from 0.1-15.8 F. Variability in the
middle and high baseline groups was 1.8-5.9 and 0.4-3.0 F.
respectively, with standard deviations higher in relation-
ship to the means than is normally observed in such distri-
butions. This finding may surprise those who would tend to
think that persons with low baseline temperatures would find
it easier to raise their temperature than those with higher
baselines. This study finding should not be regarded as
definitive evidence on this point.

Ho5: There will be no interaction effect of
baseline temperature and similarity of feedback response on
change of skin temperature.

No interaction effect on temperature was evidenced
and this hypothesis could not be rejected. The cell means
were as follows: \( A1B1 = 2.01, A1B2 = 1.87, A2B1 = 4.08, \)
\( A2B2 = 2.9, A3B1 = 6.54, \) and \( A3B3 = 6.66. \) The F ratio
obtained in making the comparison was \( F = .3, p > .05 \) (See
Tables 3 & 4). Thus baseline temperature of a subject does
not appear to have a differential effect on those subjects
who received matched signals versus mismatched signals.

Summary of Findings

The purpose of this biofeedback research study was
to test whether similar or dissimilar feedback contributed
to an increased rate of learning to control skin tempera-
ture. This study was limited to subjects with tested visual
or auditory modalities. Similarity of feedback is defined
as having the biofeedback signal and the researcher
instruction to subjects in the same modality as the tested
preferred learning modality of the subjects. Thus in the
condition of similarity, visual subjects received verbal
feedback loaded with visual terms and visual signals from
the biofeedback equipment. In the dissimilar condition,
those with tested visual modality received auditory
instructions and equipment signals. The same considerations
applied to auditory subjects. Change score temperatures
were examined to see if there was a significant difference
in the amount of temperature change that a subject could
achieve while learning to control fingertip temperature
during a skin temperature biofeedback training session.
Five null research hypotheses were formulated for this
study. Four hypotheses were accepted and one was rejected
Table 4

2x3 Analysis of Variance for Baseline Data

Means and Standard Deviations for Dependent Variable

<table>
<thead>
<tr>
<th>Treat</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td>A1B1</td>
<td>2.01</td>
<td>1.02</td>
<td>9</td>
</tr>
<tr>
<td>A1B2</td>
<td>1.87</td>
<td>.88</td>
<td>11</td>
</tr>
<tr>
<td>A2B1</td>
<td>4.08</td>
<td>1.23</td>
<td>11</td>
</tr>
<tr>
<td>A2B2</td>
<td>2.9</td>
<td>.85</td>
<td>9</td>
</tr>
<tr>
<td>A3B1</td>
<td>6.54</td>
<td>4.49</td>
<td>11</td>
</tr>
<tr>
<td>A3B2</td>
<td>6.66</td>
<td>4.73</td>
<td>9</td>
</tr>
</tbody>
</table>

Analysis of Variance for Completely Randomized Design

<table>
<thead>
<tr>
<th>Source</th>
<th>Sums of Squares</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2.39</td>
<td>1</td>
</tr>
<tr>
<td>AB</td>
<td>4.7</td>
<td>2</td>
</tr>
<tr>
<td>Error</td>
<td>417.95</td>
<td>54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
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<td>14.37</td>
</tr>
<tr>
<td>B</td>
<td>2.38</td>
<td>.31</td>
</tr>
<tr>
<td>AB</td>
<td>2.35</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>7.74</td>
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</table>
as being significant. The significant finding that emerged was that subjects who received matched instructions and biofeedback signal demonstrated significantly larger change score temperature increases than those who received mismatched instructions and biofeedback signal. Thus, within the limitations of a single training session some evidence of the benefit of matching was demonstrated.

Matching or mismatching did not produce significant results when auditory or visual subjects were studied as separate groups. Baseline temperature also did not constitute a significant main effect nor did it interact with the matching condition to produce an interaction effect.
CHAPTER 5

SUMMARY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

Summary

The primary purpose of this research study has been to examine the possibility of finding an improved method of biofeedback learning to help individuals control their skin temperature, thereby improving the benefits of biofeedback training. The approach used provided for the identification of each subject’s primary learning modality or learning style and then giving each subject matched or mismatched biofeedback signals and researcher instructions to see how learning was affected. To determine the level of modality functioning, eighty-six possible subjects were given the Swassing-Barbe Modality Index, and those sixty individuals who tested as being either auditory or visual were accepted as participants in the study.

Temperature change score from baseline to post treatment was the criterion variable under study. The hypotheses which were analyzed arose out of "within" auditory and "within" visual group comparision. Also other hypotheses originated out of a 2x3 factorial design that had the matched/mismatched condition as one independent variable and level of baseline temperature as the second variable. Significantly greater temperature change was achieved by
subjects who received a feedback signal and instruction that matched their tested primary learning modality than when mismatching was effected.

Conclusion

It is concluded that the experimental procedure used in this study was effective. It is also concluded that learning to influence one's hand temperature with biofeedback procedure is aided by using equipment signals and trainee instructions that match the primary learning modality of the subject.

Limitations and Recommendations

The majority of subjects who participated in this study were undergraduate student volunteers. While one cannot safely generalize from this group to the overall population, there is no immediate reason why the adult population in general might not respond in the same way as did the undergraduate subjects in this study.

Most of the subjects in this study were seen in a small room that was located in the Media Center on the California State University, Hayward campus. The researcher did not have control of the temperature in this room, which was often very warm. This may have caused some individuals to register a higher baseline temperature than they otherwise may have had, thus complicating the question of temperature change for them. It is recommended that any
similar or future study control room temperature within normal room temperature ranges.

In addition, it is also recommended that the modality testing segment of this study should be done in one thirty-minute session apart from the biofeedback session. It is further recommended that the biofeedback training session be scheduled at least one day after the modality testing. This should be done in order to alleviate any feeling of being tired that a subject could experience as a result of the modality assessment situation.

Another limitation of this study was the small number of auditory subjects. Although this number of auditory subjects did not prevent a significant finding from emerging, it is suggested that further studies increase this number to thirty or more.

A possible limitation of this study was the use of the Swassing & Barbe Modality Index. Some of the initial standardization work on the Swassing-Barbe Modality Index was done with children, which might conceivably affect the assessment of adults. However, this instrument has been used in previous research studies with adults (1988, Miller; 1980, Bradbury), and my observations were that the Swassing-Barbe Modality Index functioned effectively and provided adequate modality assessment of adults.

Although this study utilized skin temperature biofeedback, the procedure used in the biofeedback training session may be applicable to other biofeedback procedures,
such as EMG. Since EMG equipment provides for an auditory and visual feedback signal, this training technique could be used in that modality without any modification.

Although these research findings cannot be generalized to kinesthetic modality individuals, it appears that a similar training method could be used for these subjects. It is recommended that kinesthetic subjects be included in the subject population for those who want to look into this area. Kinesthetic modality referents are available for verbal instruction purposes, but a kinesthetic biofeedback signal would need to be devised. It is hoped that the research that has been presented will encourage others to explore some of these ideas and questions further.
REFERENCES
REFERENCES


APPENDIX A
AUDITORY MODALITY REFERENTS

squeaking
declaring
hear
hark
ring
howl
loud
octaves
crack
mouth
call
mouth
proclaim
tune
mouth
shout
wordless
sound
clap
shouting
resounding
declare
soundproof
discourse
tonal
rattle
crash
clatter
sounds like
crique
scream
scream
silence
silence
noisy
noisy
melody
melody
harmonize
harmonize
yelling
yelling
whisper
whisper
hum
hum
sing
sing
overheard
overheard
jingle
jingle
broadcast
broadcast
all ears
racket
holler
tranquil
chirp
vocal
gongs
clink
clink
resonate
rem悼
trumpet
trumpet
hark
hark
hushed
hushed
racket
lament
rattle
toll
toll
boom
chirp
voice
voice
blare
boisterous
blare
yodel
yodel
growl
growl
wordless
clamour
rumble
rattle
creak
creak
announce
announce
howl
howl
outcry
screech
bang
explosion
bang
riot
bang
VISUAL MODALITY REFERENTS

glowing  peek
blush    spy
flush    survey
impression gawk
illusion peruse
spectacle scan
goal    gape
glowing  eyeball
gaze     view
light    behold
ray of hope witness
glare    observe
look ahead lay eyes on
red ink  look upon
lightning squint
flash    sight
clear    examine
colors   peer
eye      ogle
focus    spot
insight  inspect
picture  envisage
glance   detect
point of view scout
scene    look after
twinkle  glimpse
blindly  look
bright   enlighten
bright   mind's eye
dazzling shadow
envision image
expose    blink
examine  overlooked
faded     see
hazy      stare
illuminating watch
opaque    sunny
perceive  blurred
visualize sparkle
transparent notice
notice    muddy
vague
APPENDIX B
INSTRUCTIONS FOR SUBJECTS IN AUDITORY FEEDBACK

Now that we have completed the baseline reading, I would like to explain the kind of feedback you will be receiving. You will be hearing a tone, which will be your signal about your skin temperature. As your hand temperature rises you will hear an increase in pitch. As your hand temperature decreases, you will hear the pitch go down. This is what it will sound like (demonstration). The goal of this training session is for you to learn how to increase your hand temperature.

Since this is your first biofeedback experience, this continuous display of your skin temperature may be a new and different way of listening to your body. As your body speaks to you and as you tune into your body, you may discover internal feelings and internal sensations that will be associated with different hand temperatures. You will probably become more aware of your thoughts, feelings and bodily sensations, as you listen to the effect these have on your hand temperature. You will become more aware of what you naturally and normally do to increase your skin temperature. This increased awareness and sensitivity will allow you to learn what your body feels like when this occurs. Such learning of internal cues or learning what your body feels like at certain times, can allow you to achieve some bodily changes on your own. As stated before, the object
of this study is to see if you can read your body's signals in such a way as to enable you to elevate your skin temperature.

As an aid in accomplishing this, you are encouraged to entertain various thoughts, words and sounds of any kind. For instance, the roar of a waterfall, a harmonious melody, some tranquil music, a babbling brook, or the crackling, hissing sound of a fire are some thoughts or sounds that people might use. You may want to use some of these things and then observe what happens to your body by way of the instrument feedback. Remember, as you listen to the tone it will help you to know when you are increasing your hand temperature. I will also be announcing your readings at one-minute intervals. In addition, I will be supplementing the instrument feedback with verbal comments as may be necessary in order to clarify the feedback information.

If you are ready, let us begin. As you sit comfortably and quietly, begin to be aware of any thoughts, feelings or sensations that you may be experiencing. Remember that what you are trying to do is to determine what body sensations can be related to an increase in hand temperature. Do not try to force things to happen, simply be aware of body signals and let the responses be fed back to you by the equipment. As your fifteen minute period begins, your fingertip temperature is _____.

...... (training session will be conducted).
Our time is up and I want to thank you for your participation. If you have any questions, I’ll be happy to answer them.

(This section is verbally loaded for subjects receiving auditory feedback. Words that have been underlined represent auditory modality referents).
INSTRUCTIONS FOR SUBJECTS IN VISUAL FEEDBACK

Now that you have completed the baseline reading, I'd like to explain the kind of feedback you'll be receiving. You will be seeing a digital display, which will be your signal about your skin temperature. As your skin temperature rises, you will notice the numbers on the display increasing, reflecting an increase in your skin temperature. As your skin temperature lowers, the numbers will decrease, which will reflect a decrease in your skin temperature. Please watch the display for a few seconds in order to become familiar with the readings of your finger temperature. This is what it will look like (demonstration). The goal of this training session is for you to learn how to increase your hand temperature.

Since this is your first biofeedback experience, this continuous display of your skin temperature may be a new and different way of watching your body. As you focus on your body and your body's reactions, you may discover internal feelings and internal sensations that may be associated with different hand temperatures. You will probably become more aware of your thoughts, feelings and bodily sensations, and the effect these have on your hand temperature. You will also become more aware of what you naturally and normally do to increase your skin temperature. This increased awareness and sensitivity will allow you to
learn what your body feels like when this occurs. Such learning of internal cues or learning what your body feels like at certain times can allow you to achieve some body changes on your own. As stated before, the object of this study is to see if you can read your body's signals in such a way as to enable you to elevate your skin temperature.

As an aid in accomplishing this, you are encouraged to let your mind visualize a scene, picture various lights or colors or simply allow your mind's eye to create anything you choose. For instance, a clear, bright, sunny day at the beach, a dazzling, glowing, rose, orange and crimson sunset, or a bright, sparkling, stream that winds along a path in a serene forest are some of the visualizations or colors that people might use. You may want to use some of these things and then observe what happens to your body by way of the instrument feedback. Remember, as you watch the display, it will help you to know when you are increasing your skin temperature. In addition, I will be supplementing the instrument feedback with verbal comments as may be necessary to clarify the feedback information.

If you are ready let us begin. As you sit comfortably, begin to be aware of any thoughts, feelings or sensations that you may be experiencing. Remember that what you are trying to do is to determine what body sensations can be related to an increase in hand temperature. Do not try to force things to happen, simply be aware of body signals and let the responses be fed back to you by the
equipment. As your twenty minute period begins, observe your skin temperature reading.

........(training session conducted)

Our time is up and I want to thank you for your participation. If you have any questions, I'll be happy to answer them.

(This section is verbally loaded for subjects receiving visual feedback. Words that have been underlined represent visual modality referents).
APPENDIX C
CHARACTERISTICS OF VISUAL MODALITY INDIVIDUALS

The visual learner likes to look, examine, and read about things.

She is, on the whole, quieter, more organized, and more deliberate than other children.

Her surroundings (the way her environment looks) are important to her.

She organizes by size, by color, or by some other visual cue. She is pleased with visual order.

She likes to help with classroom displays and things on the bulletin board. If there is something new or different in the classroom or if there is a mistake on the blackboard, she is the first to notice.

The visual person understands his/her world by looking at it, or by creating and imagining whatever she cannot actually see. The visual child would rather read a story than listen to it being read. They want to see the pictures.

A visual child frequently chooses a book by the picture on the cover or its illustrations. The older child enjoys reading, especially descriptive writing and stories with vivid imagery.

She likes to draw, to doodle, and to include more detail in her drawings. Noise is less distracting to the visual child, especially if she is busy reading or drawing.

A visual child comprehends more readily and shows a better memory when visual aids are presented. A lesson on phonics, for instance, tends to be harder for the visual child unless she has something, such as a printed word, a symbol, or a picture, which can help her to visualize the sound.

If she is asked to just listen to something her mind tends to wander. She often finds something interesting to watch outside the window.

At any age the visual person has trouble remembering verbal directions or messages. She asks to have such things repeated or she learns to take notes.

The high school or college student studies by looking over her notes, and once she gets involved in studying and reading, she is quieter than most students.
CHARACTERISTICS OF AUDITORY MODALITY INDIVIDUALS

When things seem too quiet, when the child is bored, or when he is studying, he likes to make noise. He might sing, or hum, or talk to himself. He likes music, especially things with rhythm and interesting sounds.

He may be a good oral reader, and he likes to talk about stories, but when he reads silently he tends to move his lips. The older child learns not to move his lips, but he continues to say the words to himself as he reads. This accounts for his being a slower reader.

The auditory child prefers to listen to a story instead of reading it to himself. He listens intently so long as he is interested, but he is sensitive to other sounds and is easily distracted.

The auditory child does well in phonics and spoken languages. He tends to find writing and arithmetic more difficult. He often talks to himself or counts aloud to solve problems.

The auditory learner understands the world by hearing about it and talking about it. He likes to discuss what he is doing. He plans future events by talking about them with someone.

He learns more readily and remembers better with oral directions and instructions. He may have trouble understanding visual stimuli, such as maps and diagrams unless the teacher gives a verbal explanation of them.

When the auditory learner wants to remember something, he verbalizes it to himself. A telephone number, an important date or name, directions in class, whatever it is he wants to retain, the auditory person says it to himself.

The older student studies for a test by reading his notes to himself or by talking over the material with others.
CHARACTERISTICS OF KINESTHETIC MODALITY INDIVIDUALS

The kinesthetic learner tends to find the confinement of the classroom an inhibitor to learning. Large muscle development may occur earlier for the kinesthetic child than for other children, but traditional classroom programs restrict the use of large muscles. He has difficulty sitting still.

This child needs to wiggle, to move his hands, his arms, and his head. He is usually the one in the class who points when reading, and he gestures a lot when talking.

The kinesthetic learner tends to respond physically when listening to a story. For instance, when the character in a story jumps up, he responds by jumping up himself. If he is not allowed to react in this manner, his attention wanes and he wanders.

The kinesthetic child copes with problems by physically grasping at them. This frequently results in his dropping things. The young child’s pencil is often very short, partly because he pushes harder on the pencil, but also because he has discovered that getting up and sharpening his pencil is an acceptable kind of movement in the classroom. He is usually eager to do anything that involves movement and is considered permissible. He likes any chance to get out of the classroom.

The kinesthetic person communicates kinesthetically all his life.

They like verbs and action words. He touches people more frequently to get their attention or to make a point. He tends to stand closer to the person he is talking to, particularly while he is still young and has not yet learned that some people are bothered by physical closeness.

He responds to physical rewards, like a pat on the back for a good job. He in turn compliments and celebrates by touch and movement, like teammates who congratulate each other by pounding one another on the back and slapping and jumping into the air.

The kinesthetic person depends on movement.