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The Effect of Biofeedback Training on Muscle Tension and Skin Temperature

Purpose

The purpose of this lab was for subjects to train themselves to increase their skin temperature, measured on the index finger of their nondominant hand, and to decrease their muscle tension, measured over the frontalis muscle, by using biofeedback training. This study is based on the research of Miller and Brucker (1979), which demonstrated that smooth muscles could experience operant conditioning.

Methods

Subjects

Seven subjects were used in this study: five female and two male. The subjects were the undergraduate students of Dr. Jo Wilson in her honors psychophysiology class at Wittenberg University in Springfield, Ohio. All subjects were in their early twenties.

Apparatus

Equipment used in this lab included an Apple Microlab system configured to measure (1) skin temperature through a thermode taped with paper surgical tape onto the index finger of the subjects' nondominant hand and (2) frontalis muscle tension via three electrodes placed over the frontalis. When subjects' skin temperatures were more than the means for the previous 90-second intervals, the computer emitted a tone. It also emitted a tone when muscle tension in the frontalis was less than the mean of the previous interval. See the procedure section for exact electrode placement specifications.

Materials

Materials used in this lab included paper surgical tape, alcohol to clean off the forehead, conducting gel, wire, electrode collars, and a chair.

Procedure

Upon arriving at the lab, the researchers turned on the Apple Microlab computer. With the aid of Dr. Wilson, subjects had either electrodes attached to their forehead or a thermode attached to the nondominant hand's index finger. The treatment order was random for each subject, and it was reversed for his or her second biofeedback session. The forehead was swiped with alcohol to clean the skin. Electrodes with conducting gel were placed over the frontalis muscle by putting the ground electrode in the center of the forehead and the white electrodes two inches on either side of the center of the forehead. Pre-measured electrode collars allowed the researchers to place the conducting gel on the electrodes, peel off the backing on the collar, and place it on the subjects' forehead. The researchers still made sure the electrodes were placed properly. The wire running from the electrodes to the computer was then taped to the subjects' back so it would be out of the way. Subjects were then seated in a comfortable chair with their back to the computer.

Depending on the experimental condition, subjects were told to reduce their frontalis muscle tension by relaxing and even thinking of holding something warm in their hands. They were told that they would know they were meeting the goal when they heard a tone emitted by the computer.

Each session began with a 90-second baseline period, followed by fifteen 90-second trial periods. During each trial period, a tone was emitted by the computer each time the subjects' frontalis muscle tension was below their mean tension for the previous trial; the tone served as the rewarding stimulus in the operant conditioning paradigm.

When skin temperature was to be measured, a thermode was attached to the index finger of the subjects' nondominant hand with surgical tape. The wire running from the thermode to the computer was taped to the back of their hand so it would be out of their way. Then a 90-second baseline period occurred, followed by fifteen 90-second trial periods. During each trial period, a tone was emitted by the computer each time the subjects' skin temperature was above their mean temperature for the previous trial; once again, the tone served as the rewarding stimulus in the operant conditioning paradigm.

Results

The results of this lab were generally similar (Tables 1 and 2). All subjects demonstrated the ability to increase their skin temperature and decrease the tension in their frontalis muscle in at least one of their sessions. Five subjects were able to increase

Table 1
Skin Temperature in Degrees Fahrenheit during Sessions 1 and 2

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7
Baseline, Session 1	75.2	77.3	78.5	74.3	78.0	67.7	75.1
Mean skin temp, Session 1	79.3	85.6	78.5	74.4	83.2	73.5	72.6
Mean minus baseline, Session 1	4.1	8.3	0.0	0.1	5.2	5.8	−2.5
Baseline, Session 2	77.9	80.1	69.5	80.9	67.2	73.7	88.0
Mean skin temp, Session 2	79.9	86.3	70.7	84.6	76.8	79.7	88.8
Mean minus baseline, Session 2	2.0	6.2	1.2	3.7	9.6	6.0	0.8
Overall average of mean skin temp minus baseline	3.1	7.3	0.6	1.9	7.4	5.9	−0.85

their skin temperature in both sessions; the same number decreased their muscle tension in both trials.

The majority of subjects (five) were able to both increase the skin temperature of the index finger of their nondominant hand and decrease the tension of their frontalis muscle more during the second trial than the first.

Table 2
EMG of the Frontalis Muscle in Microvolts for Sessions 1 and 2

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7
Baseline, Session 1	4.4	4.5	2.8	3.8	7.9	3.1	2.4
Mean EMG, Session 1	2.1	1.4	1.7	3.2	2.0	3.7	3.2
Baseline minus mean, Session 1	2.3	3.1	1.1	0.6	5.9	−0.6	−0.8
Baseline, Session 2	4.1	2.3	3.0	2.9	11.1	6.5	1.9
Mean EMG, Session 2	1.3	1.3	1.4	2.3	2.5	3.2	1.4
Baseline minus mean, Session 2	2.8	1.0	1.6	0.6	8.6	3.3	0.5
Overall average of mean EMG minus baseline	2.6	2.1	1.4	0.6	7.3	1.4	−0.15

Specifically, subject 7 had atypical results. This subject's overall average skin temperature was less than the baseline value; the subject's overall average muscle tension was more than the baseline value.

Discussion

The bulk of the data collected in this study validated the research of Neal Miller; the subjects appeared to undergo operant conditioning of their smooth muscles in order to relax their frontalis muscles and increase their skin temperatures. Subjects 3 and 6 each failed to do this in one session; subject 7 failed to do this several times. This finding is difficult to explain precisely. It is possible that for subjects 3 and 6, this data was a fluke. For subject 7, it is likely that the subject was simply stressed due to outside factors before arriving for the first trials of EMG and skin temperature, and this stress skewed the data.

The effect of biofeedback training was generally greater as the operant conditioning became better learned. Learning was indicated by the finding that the majority of the subjects performed better on the second trials than on the first trials. This finding shows the effectiveness of biofeedback on reducing factors associated with stress, like muscle tension and low skin temperature; biofeedback's impact is even greater when it is administered over time. The implications of this information are without limits, especially for the treatment of a variety of medical disorders.

There were a few problems with this lab. The subjects all were at different levels of relaxation to begin with. It is impossible to determine the effects of outside events, like exams or other stresses, on their EMG and skin temperature levels. Skin temperature itself could have been altered by cold outside temperatures. Being in a lab may have altered the stress level of some subjects, and noises from outside the lab may have had an effect as well.

If this study were repeated, it would be a good idea to let subjects simply be in the lab for a period of time before measures are taken. This would allow the effect of outside temperature to be minimized. It would also reduce the effect of getting used to the lab, decreasing the orienting response. Finally, it would also be good to do the experiment in a soundproof room.

Reference

Miller, N. E., & Brucker, B. S. (1979). A learned visceral response apparently independent of skeletal ones in patients paralyzed by spinal lesions. In N. Birnbaumer & H. D. Kimmel (Eds.), *Biofeedback and self-regulation* (pp. 287–304). Hillsdale, NJ: Erlbaum.