The effect of intermittent auditory stimulation on the occipital alpha rhythm

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Three groups of college students were monitored for alpha EEG production during eight daily sessions lasting 46 min each. No differential treatment was in effect for the first two sessions in which baselines were established. Over the subsequent six sessions, the feedback group received auditory stimulation (clicks) contingent upon alpha production, the taped-feedback group received the same type of auditory stimulation in a noncontingent fashion, and the control group received no auditory stimulation. Unexpectedly, the taped-feedback group showed the most reliable increases in alpha production (relative to baseline) over the six treatment sessions. Only half of the contingent feedback subjects demonstrated reliable increases, mostly during the last two sessions, while no control group subject showed reliable increases. The importance of using both a noncontingent feedback group and a no-feedback group in alpha conditioning studies is stressed.

Black (1974) has noted that the most frequently cited uses of operant CNS conditioning are: (1) to provide a method for controlling internal neural and psychological processes, mainly for therapeutic reasons; (2) to provide an analytical tool for studying the neural systems of which the reinforced pattern of CNS activity is a component; and (3) to provide information on the mechanisms of operant conditioning.

Lynch and Paskewitz (1971) have noted that there is often insufficient evidence to justify discussion of the "operant control of alpha activity." These authors' objections are concerned with the inability of experimenters to control constitutional, physiological, and cognitive-attentional factors through which alpha activity is apparently mediated. Therefore, further discussion is "operationally indefensible." Williams (1975) has objected on similar grounds and has deemed it preferable to speak in terms of self-control or feedback control rather than operant control.

Engstrom, London, and Hart (1970), while investigating the relationship between hypnotic susceptibility and the alpha rhythm, noted that subjects who received false feedback showed an increased incidence of alpha similar in magnitude to those receiving contingent feedback. Strayer, Scott, and Bakan (1973), while examining the role of contingent feedback in an alpha training procedure, noted similar results. However, these studies did not

employ no-stimulus groups as a means of controlling other variables within the experimental situation. Hart (1968) was apparently the first to suggest that a need for such groups existed since some of his control subjects also showed alpha increments.

Travis, Kondo, and Knott (1974a) reported that with an eyes-open paradigm and blue light as the feedback stimulus, an experimental group receiving relevant feedback produced significantly more alpha/time than did a yoked-control group and a no-stimulus control group. The authors suggested further that the increases in alpha demonstrated by Hart's (1968) no-stimulus control group may have been due to spontaneous increases in alpha at lower voltages, since no amplitude criterion had been specified. These changes could occur without a change at or above a criterion level.

Travis, Kondo, and Knott (1974b) assessed the performance of a large number of subjects on both eyes-open and eyes-closed alpha training tasks. Additionally, the authors employed both binary and proportional feedback. They reported no differences in groups receiving contingent, random, and no binary feedback (the type used in studies thus far cited). Although a significant trials main effect was noted, further examination revealed that the significance was due to increases following initial decrements, rather than increases from baseline.

Nideffer (1973) suggests that increases in alpha may be related to at least two other factors aside from learning. First, alpha could increase as a function of habituation to the experimental situation. Schwartz (1974) has stated that 40 min/day of sitting quietly has about the same effect on alpha production as 40 min of daily meditation. The relationship between high levels of alpha production and meditational practices has been demonstrated

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by several authors including Kasamatsu and Hirai (1969) and Anand, Chhina, and Singh (1969). The second proposition is that the tone used to provide feedback may assist in the development of alpha. That is, it may serve to inhibit intrusive thoughts which would interfere with alpha production, although there is no empirical evidence to support this notion.

These proposals provided the framework for the present study. The hypothesis was that there would be significant differences in the production of alpha (alpha/time) between groups of subjects which: (1) received operant alpha training (feedback group), (2) received prerecorded intermittent auditory stimulation (taped-feedback group), or (3) control subjects who were required only to sit quietly during the recording periods.

METHOD

Subjects

Seventeen subjects, nine male and eight female, ranging in age from 17 to 27 years, were drawn from the student body of Ramapo College. Three additional subjects (not included in N) dropped out during the course of the study due to the lengthy procedure. Subjects who were currently practicing meditation, taking medications, or had family histories of neurological disorders were excluded from the study. Subjects were asked to refrain from smoking cigarettes and drinking coffee, tea, or alcoholic beverages prior to each day's session. Subjects reported complying with this request.

The subjects were assigned to either the feedback group ($N = 6$), the taped-feedback group ($N = 5$), or a control group ($N = 6$). The subjects reported to the laboratory 4 days/week at the same time of day, or as near to the same time of day as their schedules permitted. One subject from the taped-feedback group completed two sessions within 3 h.

Apparatus

A Cyborg P431 alpha monitor was used to separate the alpha components from the subjects' EEGs. The P431 is essentially a narrow bandpass filter with a width of 5-15 Hz. A monopolar recording was made from position Oz of the International 10-20 system, referred to the right earlobe. The subject was grounded at the left earlobe. A binary signal from the P431, indicating the presence of alpha, was used to activate a BRS/LVE running time meter. Intervals within each session were timed by two BRS/LVE timers.

The feedback signal was a series of clicks produced by the P431 in the presence of alpha greater in amplitude than the threshold value ($20 \mu V$) set by the experimenter. The subject was asked at the beginning of the session to inform the experimenter when the volume of the signal was at a comfortable level. This setting was then maintained for the entire session. The feedback signals were delivered through a set of Realistic Nova 10 headphones.

Auditory stimulation for the taped-feedback group was provided by recording a feedback subject's signals on a Wollensak Model 4860 cassette tape recorder for two sessions.

A Lafayette visual choice reaction time apparatus was used between recording periods as a means of keeping subjects awake during the session.

Procedure

Subjects were seated in a comfortable chair inside a small

cubicle with a low level of background noise (35-40 dB). Ambient lighting filtered in through a partially blocked window in the door behind them. The level of light inside was well below 1 fc. Data-collection instruments were located in an adjacent room.

After proper electrode placement was insured, subjects were instructed as to the requirements of the session. Each session was divided into four 10-min recording periods. The beginning of the initial period was signaled by a 2.8-kHz tone to which the subject responded by pressing a key on the reaction time device. A single tone again signaled the end of each 10-min period. The end of the session was signaled by two tones in series. Each 10-min period was followed by a 2-min interval during which the subject responded on a reaction time task to one of four different colored lights presented from 4 to 16 times.

The initial two sessions were used for the recording of baseline measures. Subjects were instructed to sit quietly with their eyes closed, and to avoid movement, especially of the face and neck, during the recording periods. These instructions were repeated daily. For the six additional sessions, feedback subjects were instructed that the presence of clicks indicated that alpha waves were present in their EEGs and that their incidence might be increased in some way unknown to the experimenter. Taped-feedback subjects were instructed that the signals that they were about to receive were tape recordings of a feedback subject's signals, and that they were to sit quietly and listen to them. Control subjects wore "dead" headphones and were instructed to sit quietly throughout the recording periods.

RESULTS

Mean scores for each block of 2 days were calculated. Scores from the test blocks were then transformed to percentages of their baseline blocks. Figure 1 illustrates the group scores as a function of 2-day blocks. These scores for all 17 subjects over the six test blocks were then arranged in ascending order, and the overall median (107.1%) was located. A distribution-free analysis of variance (Wilson, 1956) was used to analyze the data because of the small N and since it could not be assumed that alpha was normally distributed. The main effect of

Figure 1. Mean percent-of-baseline scores for the three groups as a function of 2-day blocks.

groups was found to be significant ($\chi^2_r = 11.83$, $df = 2$, $p < .01$).

Figure 2 represents the number of scores in each group that fell above the median. This statistical analysis is not sensitive to interactions in which curves do not "cross"; however, as can be seen in Figure 1, the difference in performance changes for the three groups over days was marked. Although the final performance of the feedback and taped-feedback groups was essentially the same, the latter showed monotonic increases. The performance of the subjects in the feedback group was essentially as described by Kamiya (1974). Some subjects failed to reach scores that were consistently higher than their baseline scores. Two subjects showed consistent decreases in the incidence of alpha. Figure 3 illustrates the performance of the individual subjects as a function of 2-day blocks.

DISCUSSION

From the results of the taped-feedback group, it can be concluded that the presence of intermittent auditory stimulation can be a sufficient condition for increases in alpha production. This type of noncontingent feedback is similar to the random control procedure specified by Rescorla (1967), and the necessity of including it in bio-feedback research is obvious. The results of previous studies showing increases in alpha with contingent feedback are open to question if they have not made use of a noncontingent feedback control group. Otherwise, increases in alpha cannot be attributed to the operant feedback contingency per se, and may simply be manifestations of

Figure 2. The median for all Figure 3 scores in Blocks 2, 3, and 4 (51 scores in all) was found. The above figure shows how many scores fell above this median for the taped-feedback group (T), the contingent-feedback group (F), and the control group (C). Of all scores falling above the median, 50% of them came from T, 31% came from F, and 19% came from C.

Figure 3. Performance of individual subjects in the feedback group (A), taped-feedback group (B), and control group (C). Mean percent-of-baseline scores are plotted as a function of 2-day blocks. Note that the ordinate scale for Panel C is different from that of Panels A and B.

stimulus-elicited behavior. This phenomenon has been noted with visual stimuli (Morrell, 1966) and falls into the category of stimulus-provoked alpha activity.

The fact that the control group showed no consistent increases in alpha demonstrates that the increases of the other two groups cannot be accounted for by simple habituation to the testing situation over the eight sessions.

Inspection of Figure 3c indicates that two subjects showed initial increases above baseline levels despite a criterion of $20 \mu V$. Thus, Hart's (1968) suggestion of the need for no-stimulus controls is supported by the present data. The proposal of Travis et al. (1974a) that spontaneous increases in alpha could occur at lower voltages without a change above a criterion level requires further examination. The fact

that the alpha levels of the two subjects showed initial increments followed by a return to baseline emphasizes the need for lengthier studies than are commonly reported. The results of Travis et al. (1974a) may have been, as the authors stated, due to the relative brevity of the procedures as well as methodological differences (e.g., eyes-open paradigm, blue-light feedback). The failure of Travis et al. (1974b) to find significant differences between binary feedback subjects and their controls may have been, as they suggested, a function of the type of feedback employed, since they demonstrated that proportional feedback was most efficient in the rapid development of alpha in eyes-closed training. This procedure was also relatively brief compared to the present study as well as previously cited studies (Engstrom et al., 1970; Hart, 1968; Strayer et al., 1973).

Although alpha increases due purely to an operant feedback contingency were not shown in the present study, it is still possible, as Nideffer (1973) suggests, that this technique may be used beneficially in training subjects to control their alpha rhythms. It is possible that the more auditory stimulation a subject receives initially, the more alpha he will produce ultimately. If this is true, it may be more desirable to begin alpha training with several sessions of noncontingent auditory stimulation. These sessions may result in a higher incidence of alpha due to the subject's habituation to the feedback tone. If this is the case, the orienting response and general arousal to a novel auditory stimulus might be eliminated, and learning of the feedback contingency may proceed at a more rapid rate. This hypothesis would seem to be worth testing since Martindale and Armstrong (1974) have noted that some subjects quickly reach a barrier to further increases in alpha production.

Alternatively, by taking a subject's raw EEG and multiplying its frequency by 200, a signal analogous to the actual events taking place in the brain may be manufactured. By using the signal as continuous feedback, the combined effect of auditory stimulation and additional information about what is occurring during nonalpha states may aid the subject in gaining control over his alpha EEG.

Beatty and O'Hanlon (1975), in a reply to Williams (1975), have noted that the term "operant" adequately characterized the methodology of such experiments, despite the inability to control for all subject factors. These authors had considered the terms "feedback" and "self-control" but rejected both—the former because it suggests a strained analogy with system control theory, and the latter because of its philosophical connotations. It would appear, then, that this argument is largely a semantic one, and the choice of terms, therefore, a personal

matter. The lack of a standardized language is a problem that has plagued psychology in every phase of its history. Although the effects of an operant contingency were not clearly demonstrated in the present study, it would seem that the use of operant conditioning terminology, due to its clarity of operational definition, would serve best in this application and further aid in the distribution of information.

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