Predictive Dual Process Theory for Alpha Enhancement

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Major Purpose

To present a theory of alpha enhancement which explains how feedback trainees learn (or fail to learn) alpha increases.

Kamiya's (1976) Presidential Address urged the formulation of theories for biofeedback, noting that absence of theoretical bases has retarded development of this field. Kamiya thus motivated development of this theory, which has three major features:

A. It successfully accounts for past findings in the alpha feedback literature.
B. It identifies key parameters which influence training success or failure, and it makes experimentally testable predictions about optimizing those parameters in a variety of settings.
C. It generates testable predictions about clinical applications of alpha enhancement training:
1. Differential effectiveness with differential clinical groups.
2. Differential enhancement strategies required for hypo- and hyper-aroused subjects.

Subjects (sources of data for the theory's

development)

Alpha acquisition curves from several long term studies were found to have similar UP-DOWN-UP patterns (Regestein, Pegram, Cook, & Bradley, 1973; Hardt, 1974, 1975b). Regestein, et al. trained 31 subjects in a loose, informal design (subjects could sit, lie, walk, write, sing, etc. *during* feedback). Hardt trained 32 subjects in two separate (N=16 each), more formal studies. Other essential data came from response habituation curves given by Groves and Thompson (1970) to support their theory of Dual Process Habituation.

Method:

Since 3 studies in 3 different laboratories found UP-DOWN-UP patterns in alpha enhancement training, it seemed fruitful to seek an explanation of this pattern, - especially since the pattern developed faster with controlled (and slower with uncontrolled) task orientation of trainees. Ancoli (personal communication, January 1976) noted that Groves and Thompson (1970) also showed curves with a "bump". However, inspection revealed those (response habituation) curves to be the inverse of the alpha enhancement pattern: DOWN-UP-DOWN instead of UP-DOWN-UP. Reflection on these curiously inverse patterns led to the realization that if alpha blocking responses went DOWN, alpha activity should go UP, - and conversely! This insight suggested explanatory utility. Alpha enhancement could be viewed as an example of Dual Process Habituation, wherein alpha antagonistic responses are progressively reduced or habituated. Validity of this insight was suggested by the number of prior proposals that alpha enhancement results from reduction of alpha blocking influences (Paskewitz, Lynch, Orne & Costello, 1970; Peper, 1971; Lynch & Paskewitz, 1971; Paskewitz & Orne, 1973a). However, these prior proposals led neither to predictive theories nor to understanding of how variations in training methods determined training success or

failure. The necessary inspiration for A Predictive "Dual Process" Theory for Alpha Enhancement came from viewing enhancement as, not just habituation, but as an example of Dual Process Habituation (Groves & Thompson, 1970). Working out the details of the theory then became a matter of: a) Taking over key parameters of Dual Process Theory, b) Translating them into the alpha feedback context, and c) Interpreting their influence by reference to the classical pre-feedback literature on the "natural reactivity" of alpha to stimulation.

Key parameters were:

A) Stimulus Frequency.

This is not the frequency (pitch) of a feedback tone nor color of a feedback light, but is, instead, the time rate of delivery of feedback information. Thus percent time feedback has low stimulus feedback frequency, because it provides information only when alpha voltages cross the arbitrary threshold (in either direction). However, analogue (proportional) feedback has high stimulus frequency because it provides a continuous flow of information about any and all signal changes.

B) Effective Stimulus Intensity

Feedback signals which are too intense will cause alpha blocking. Light blocks alpha more readily than sound or touch, so light has a higher "effective intensity". Not just the feedback stimulus itself, but any ambient light or sound, or any ongoing muscle activity (especially oculomotor) will also contribute to "effective stimulus intensity" (and to alpha blocking). Thus with equal feedback tone intensity, the "effective intensity" of the total setting decreases progressively as follows:

(eyes-open-light) > (eyes-open-dark) > (eyes-closed-dark)

C) "State" of the Organism

The concept of activation or arousal is vital to interpretation of habituation results. Malmo (1959) and Johnson (1969) proposed an inverted "U"-shaped relationship between alpha and arousal. Supporting this view are reports that alpha enhancement is more difficult for both over-aroused subjects (Utz & Banikiotes, 1973; Hardt, 1974, 1975a; Valle, Chisolm, & DeGood, 1975), and for under-aroused subjects (Hord, Tracy, Lubin & Johnson, 1975; Hord, Lubin, Tracy, Jensma, & Johnson, 1976).

Results of the Theory: Explanations and Predictions

A) Subjects of normal arousal enhance alpha better than hypo- or hyper-aroused subjects, e.g. low anxiety normals enhance better than high anxiety subjects. Rested subjects do better than sleep deprived subjects.

B) Analogue (proportional) feedback is superior for eyes closed training. Percent time may be better for eyes open training, especially with ambient light (cf. Travis, Kondo, & Knott, 1974).

C) Higher alpha levels will be produced with proportional feedback and eyes closed training, especially in dark, sound proof rooms.

D) Feedback modalities in increasing order of effectiveness are:

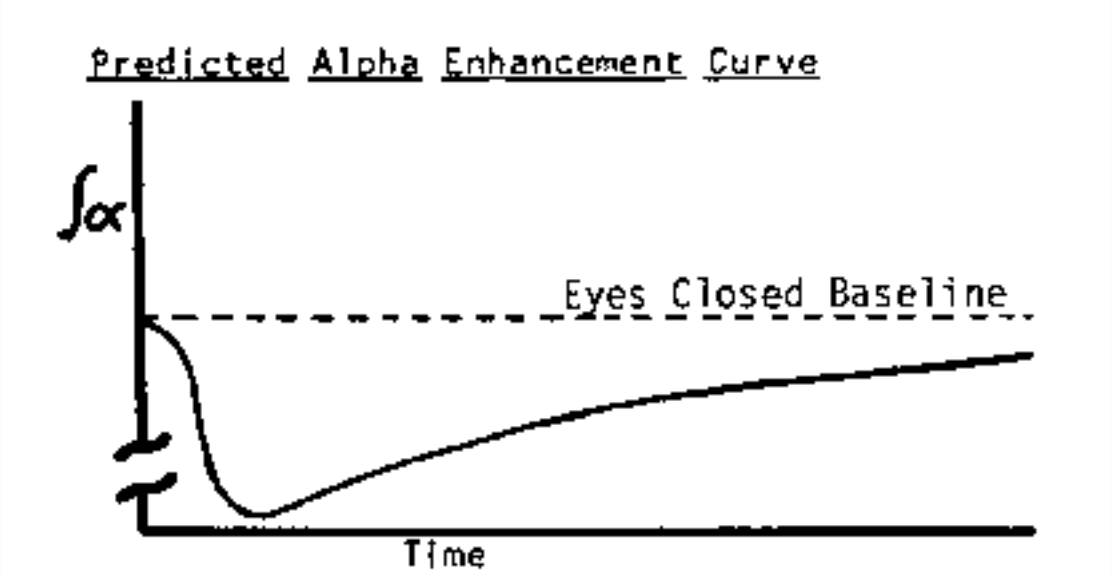
Visual < Auditory < Tactile

E) For maximum alpha increases, there should be minimal interruption of subjects during sessions, and daily sessions are better than once a week or twice a month.

F) During UP portions of the enhancement curve, the rate of increase from session to session will be inversely proportional to elapsed time between sessions (assuming sessions are not so long or closely spaced as to produce fatigue).

G) Shapes of enhancement curves depend on training conditions. With eyes open training and percent time feedback, alpha may fail to exceed eyes closed baselines. Even the shape of Paskewitz and Orne's (1973b) eyes open, percent time curve is predicted:

“Images to be placed in blank space”



H) High arousal Subjects (e.g. high anxiety) who successfully enhance alpha will use relaxation strategies, and will report alpha to be "relaxing". Low arousal subjects (flaccid muscles, torpor, depression, sleep deprived) will have to use arousal strategies to enhance alpha, and when successful, will report alpha "pleasant" or "unpleasant" depending on their use of intense, self generated *positive* or *negative* emotionality to increase their arousal levels (e.g. joy and happiness or frustration and anxiety).

I) Pronounced subjective experiences (the "alpha experience") require substantial alpha increases *above eyes-closed* baselines. Somewhat

similar experiences could be induced in subjects of average arousal by sensory deprivation of all modalities except the feedback modality, i.e. auditory feedback "alpha experiences" should be partially similar to sensory deprivation for all modalities except audition.

J) After sufficient alpha increases to produce *strong* subjective experiences, the enhancement curves will break out of the patterns seen in (G) above. At that time, alpha increases will follow a power law,

$$(\text{Integrated Alpha}) = c\,(\text{Total Feedback Time})^{\text{power}}$$

due to positive feedback (reinforcement by the highly positive subjective state). The power will exceed unity (1) during the positive feedback phase (powers as high as 20 have been observed), and will decrease to a small fraction as the alpha limit (the maximum alpha voltages sustainable by brain tissue) is approached asymptotically.

K) A proportional feedback signal with a variable constant of proportionality (Variable Transfer Function) will be best for highly aroused subjects, and might help all subjects show steady increases (G, Figure 3, above). Variable transfer function feedback would require that the gain of the feedback signal start at a very low level and then be gradually increased.

L) By repeatedly enhancing alpha above baseline, the underlying alpha blocking responses (e.g. an anxiety syndrome) will habituate out. If true "Below Zero" habituation (Groves & Thompson, 1970) can be observed in alpha enhancement, it will mean an effective treatment for anxiety can be achieved by long term alpha enhancement training.

M) Since complex responses habituate more rapidly than simple ones (Groves & Thompson, 1970), a structurally complex anxiety neurosis may be more susceptible to treatment with alpha enhancement than a simple phobia (given equal severity). Even phobias have been

successfully treated with alpha enhancement (Benjamins, 1976).

Discussion

An entire biofeedback area need no longer make its methodological choices blindly. Guided by this Predictive Theory, both researchers and clinicians can choose the best training techniques for their settings. Optimization of feedback parameters for specific individuals is also possible. Negative results in alpha training are traced to poor methodological choices, not to inability of subjects to increase alpha above baselines. Requirements for studying the "alpha experience" include substantial alpha increases above eyes closed baselines, and require that conclusions about the subjective "alpha experience" from studies without such increases be discounted (e.g. Walsh, 1972, 1974). Tests of experimental hypotheses are proposed and should stimulate further research. If "Below Zero" habituation is found in alpha enhancement, it could mean an effective treatment for anxiety. The example of this Theory's development from the "Dual Process" model, might also stimulate theory construction in other feedback areas, such as EMG training. A slide show illustrated the close match between published enhancement curves and the Theory's predictions.

References

Benjamins, J.K. "The effectiveness of alpha feedback training and muscle feedback procedures in systematic desensitization". *Proceedings of the Biofeedback Research Society*, Seventh Annual Meeting, 1976, **7**, 5.

Groves, P.M. & Thompson, R.F. "Habituation: A Dual Process Theory", *Psychological Review*, 1970, **77**, 419-450.

Hardt, J.V. "Alpha EEG responses of low and high anxiety males to respiration and relaxation training and to auditory feedback of occipital alpha", *Dissertation Abstracts, International*, 1974, **35** 1912B-1913B, Catalog No. 74-19309.

Hardt, J. V. "Relaxation during breathing feedback, yogic breathing, and alpha feedback: Effects on alpha EEG activity in low and high anxiety males". *Proceedings of the Biofeedback Research Society*, Sixth Annual Meeting, **6**, 72, Monterey, California, February 1975 (a).

Hardt, J.V. "The ups and sowns of learning alpha feedback". *Proceedings of the Biofeedback Research Society*, Sixth Annual Meeting, 1975, **6**, 118. (b)

Hord, D.J., Lubin, A., Tracy, M.L., Jensma, B.W. & Johnson, L.C. "Feedback for high EEG alpha does not maintain performance or mood during sleep loss". *Psychophysiology*, **13**, 58-61.

Hord, D.J., Tracy, M.L., Lubin, A., & Johnson, L.C. "Effects of self-enhanced EEG alpha on performance and mood after two nights of sleep loss". *Psychophysiology*, 1975 **12**, 585-590.

Kamiya, J. "Presidential Address to the Biofeedback Society", Colorado Springs, March 1976.

Lynch, J.J. & Paskewitz, D.A. "On the mechanisms of the feedback control of human alpha wave activity". *Biofeedback & Self Control, 1971*, 1971, Chicago: Aldine, 198-210.

Paskewitz, D.A., Lynch, J.J., Orne, M.T., & Costello, J. "The feedback control of alpha activity: Conditioning or disinhibition?", *Psychophysiology*, 1970, **6**, 637-638.

Paskewitz, D.A. & Orne, M.T. "On the reliability of baseline EEG alpha activity". *Psychophysiology*, 1973, **10**, 202-203. (a)

Paskewitz, D.A. & Orne, M.T. "Visual effects on alpha feedback training". *Science*, 1973, **181**, 360-363.

Peper, E. "Reduction of efferent motor commands during alpha feedback as a facilitator of EEG alpha and a precondition for changes in consciousness". *Kybernetik*, 1971, **9**, 226-231.

Regestein, Q.R., Pegram, G.V., Cook, B., & Bradley, D. "Alpha rhythm percentage maintained during 4- and 12-hour feedback periods". *Psychosomatic Medicine*, 1973, **35**, 215-222.

Travis, T.A., Kondo, C.Y., & Knott, J.R. "Parameters of eyes closed alpha enhancement". *Psychophysiology*, 1974, **11**, 674-681.

Utz, P.W. & Banikiotes, P.G. "Relationship between anxiety and the operant conditioning of alpha through feedback training". *American Psychological Association, Proceedings*, 1973, **10**, 549-550.

Valle, R.S., Chisholm, R.C., & DeGood, D. "The relationship of state and trait personality factors to alpha-controlling ability". *Proceedings of the Biofeedback Research Society*, Sixth Annual Meeting, 1975, **6**, 38.

Walsh, D.H. "Effects of instructional set, reinforcement and individual differences in EEG alpha training". *Proceedings of the Biofeedback Research Society*, Third Annual Meeting, Boston, November 1972.

Walsh, D.H. "Interactive effects of alpha feedback and instructional set on subjective state". *Psychophysiology*, 1974, **11**, 428-435.