Optimizing dimensions for EEG alpha state discrimination

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While it is often stated that neurofeedback training increases perceptual acuity for subtle internal signals about EEG states, very few studies have directly measured the human ability to discriminate between these states. The purpose of this study is to determine the stimulus dimensions that optimize this ability. EEG alpha amplitude (at Pz or F3) is calculated for each epoch, and ranked among a percentile distribution of amplitudes of the most recent 150 seconds initially derived from a baseline recording. Each session, a random order of high and low trials is generated, and a tone is sounded whenever the amplitude exceeded a critical difference from the median of the baseline. Subjects respond "high" or "low," and receive feedback about whether the response is correct (high tone) or incorrect (low tone) after each trial. At the time of this writing, three out of four subjects have achieved a significant level of performance within eleven sessions. Preliminary evidence suggests that subjects perform better with four-second discriminative stimulus intervals than one- or two-second intervals. Our observations also suggest that absolute power in the peak alpha band plus or minus one Hz is more closely associated with the discriminative stimulus than relative power or peak alpha plus or minus two Hz. Ongoing research will determine the effects of electrode location, pre-session baseline power, eye movement, and critical difference from the baseline median, on subjects' performance.

Psychophysics of EEG State Discrimination

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Nearly all research on human EEG learning since the 1960's has focused on control of EEG constructs. Learning is difficult to measure in EEG control training because thresholds are constantly adjusted based on within-subject variation, and effects of training are often smaller than the baseline variation. By contrast, a direct measurement of success is intrinsic to discrimination learning. A rigorous method of measuring a subject's perceptual acuity for discriminating EEG states could provide insight about relationships between "control" and "awareness" of these states, and a practical experimental model of EEG control training. This study investigated the ability of one subject to discriminate high from low beta/theta and relative alpha amplitude states. EEG was recorded at Fz with a linked ears reference using custom software and a Brainmaster EEG. For the beta/theta task, the subject was prompted (randomly) to respond "high" or "low" when beta/theta exceeded 20 percentiles from the baseline median. For alpha, the subject was allowed to decide when to respond, alternating, when he felt a "high" or "low" alpha state was present. Success for beta/theta was insignificant, 53% over 487 trials. Success for alpha was 66% over 1168 trials ($p<.0001$). The perceptual threshold for alpha discrimination appeared to be 30%, i.e., 0-40 and 70-100 percentile amplitude events were guessed correctly (63-84%, $p<.001$), while events in between were guessed at chance levels. "High" alpha responses were more often correct (76%, $p<.0001$) than "low" (55%, $p<.01$). These results suggest relative alpha amplitude is discriminable and beta/theta ratios might be discriminable if subjects are allowed to decide when to respond. Future studies will assess perceptual acuity between subjects and among various EEG constructs and scalp locations.