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SELF-REGULATION AS AN AID TO HUMAN EFFECTIVENESS

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ABSTRACT

This Second Annual Progress Report covers (1) the Second Annual ARPA Self-Regulation Symposium, (2) the meeting of the ARPA Review Panel, (3) the individual progress reports of the subcontractors, and (4) lists the publications during the second year.

The symposium afforded an opportunity for subcontractors to present their findings and projected research to not only other subcontractors but also to invited potential DoD users and to personnel from applied research laboratories who might take the basic research findings into more field-oriented research programs.

The discussions during the two-day meeting reflected the concern over comparable units, baseline measures, and what constituted appropriate control groups. Many expressed the view that the goal of defining specific and unique basal levels of physiological functioning that would be correlated with effective performance was probably unobtainable in the time frame of this project. Effective performance is correlated with various levels of brain, cardiovascular, vasomotor, and muscle activity. The physiological pattern associated with effective functioning tends to vary within a single subject over time and with different tasks and it is extremely unlikely that a common physiological pattern will be found over subjects.

Instead of searching for effective patterns or attempting to modify basal levels in normal, nonstressful states, it was suggested that self-regulation would probably have its greatest value in training subjects to overcome the disruptive effects of stress, fatigue, pain, sleep loss, or other performance debilitating conditions. It was also the view of many that self-regulation would be of potential value for specific personnel assigned to unique tasks and, at this

point, not applicable to large groups in routine, though often stressful, situations.

The review panel strongly recommended that subcontractors be encouraged to focus on performance measures during the remainder of the contract and to shift from parametric research studies. Where feasible, subjects should be run in stress or fatigue-inducing tasks and less effort should be given to training to maintain shifts from stable basal levels in search of optimal physiological states. A consultant with special skills in performance tasks was to be obtained to assist the subcontractors.

The subcontractors' progress reports indicated that all contractors were at the stage where more performance oriented research could be expected. Some work has already been done relating alpha activity and heart rate to performance on reaction time, memory, and other cognitive tasks. To date, no consistent significant relationship has been found. Self-regulation of muscle and theta activity appears to be an effective way to reduce arousal levels and induce sleep. An operational procedure should be perfected this next year. The possibility of reducing pain by self-regulation training is supported by pilot work on chronic and experimental pain subjects. The procedures for control of vasomotor tone have been developed to the point where field testing for control of low temperatures and frostnip are planned at the U. S. Army Research Institute of Environmental Medicine, Natick, Massachusetts, for summer 1972.

This is the Second Annual Report of the contract awarded under ARPA Order No. 1595 to conduct research to determine the relevance of physiological processes and internal states for DoD. The subcontracts awarded by the San Diego State University Foundation under this contract are listed in Appendix 1. This progress report will be divided into four parts. First, the Second Annual ARPA Self-Regulation Symposium held May 19-20, 1972, in San Diego. The list of participants presenting at the symposium and the participants attending the symposium are included in Appendix 2. Second, the meeting of the ARPA Review Panel for the Self-Regulation Program held following the symposium; third, a summary of the progress reports submitted by the individual subcontractors to the San Diego State University Foundation; and fourth, publications.

SECOND ANNUAL ARPA SELF-REGULATION SYMPOSIUM

In general, the participants were very pleased with the May symposium and felt that a very useful and effective interchange of ideas had taken place. This symposium has, as one participant stated, become one of the major meetings on self-regulation. Certainly, some of the most influential investigators in the area of biofeedback are participants in the ARPA Self-Regulation Program. As the information presented at this symposium will be summarized in the progress report section to be given below, a summary of the discussion periods would be most appropriate for this section.

In general, the discussion at the end of the first day of the meeting dealt with the problems of controls, of obtaining comparable baseline data, and of how a general agreement as to the parameters affecting EEG alpha, heart rate, skin temperature, and other variables under self-control could be obtained.

In the discussion of adequate control groups, the problem of the placebo effect was given serious attention. The nonspecific effects of biofeedback were viewed as a problem in determining whether results were specific to manipulation of a specific variable. Some felt that finding significant results at this stage of the program was the more important goal, while others felt that only studies should be done where nonambiguous cause and effect relations could be inferred. These problems are, of course, not unique to this program and are of real concern to those using biofeedback in the clinical area.

The use of yoked controls, while having the apparent advantage of giving comparable feedback to experimental and control groups, was felt to have drawbacks with respect to subject attitudes. A realization by the subject that he was not controlling the stimulus could, in many instances, lead to the subject becoming a nonparticipant in the study. Also, the problem of handling the subject's feelings after the study when he was told that he really was not controlling the stimulus could lead to unnecessary difficulty. In general, it was felt that yoked controls would not be desirable in most situations. It was recommended, instead, that subjects be given an alternate stimulus; for example, that used by Dr. Jack Beatty at UCLA where one group receives alpha feedback and another group receives beta feedback. The beta feedback, then, would be a control for the alpha feedback group.

With respect to the problem of adequate baseline, it was generally felt that most experimenters were not using baseline samples of adequate duration and were not concerned enough with the day to day shifts in baseline. It was recommended that more attention should be given to representative baseline measures, that the 5-10 minute baseline samples were not adequate, and that a standard procedure be set up to insure that baseline measures would be comparable from laboratory to laboratory, particularly within a specific area; for example, EEG alpha or heart rate.

The problem of comparable units and the problem of controlling parameters affecting the biofeedback variable focused upon the area of EEG alpha. For example, as stated by Dr. Kamiya, to be able to understand the variables that affect the level of alpha, the measurement criteria must be specified. The fact that different laboratories use different measures makes it difficult to compare results. The two parameters of measurement most important in specifying alpha are alpha abundance over a period of time and its frequency range. Most laboratories report an index of percent time that a particular frequency is present in the record, and its presence is usually noted by filter circuits which have been set to some criterion; e.g., either microvolts or some proportion of the largest amplitude seen in the record. Other laboratories report the average or the total amplitude of the alpha taken over a set period of time. For those using spectral analysis, alpha dominance is the amount of alpha activity passed through the filters and expressed as percent of alpha power relative to the total power. As Dr. Kamiya noted, when the band pass technique is used, both band width as well as the slope of the filter function are relevant, but there is little standardization among the different laboratories, and direct comparisons or even approximations of how much the different criteria affect the data are not possible. While this absence of standards was viewed as a problem, the point was also made that since there are no definitive data as to which alpha measure will be of most value for the goals of this project, perhaps it would be a mistake to lock all investigators into the same procedure. The necessity for clearly describing and defining the measure used was given unanimous support.

In the discussion on the second day, the focus was on where are we with respect to self-regulation as a possible aid to human effectiveness and what should be the future directions of the program.

With respect to questions raised on the previous day as to comparable units and whether there was comparability from one laboratory to the next, as with the problem of alpha units it was felt that at this stage of the research program the variability from one laboratory to the next was not necessarily bad. The stated goal was to have several investigators utilizing somewhat individual approaches in the initial stages to determine what were the most effective ways of achieving self-regulation and whether any one technique would be more effective as a predictor or as a correlate of human performance.

In the discussion, three points were made: (1) The initial premise of the program was that there were definitive optimal physiological states that would be associated with effective performance; (2) that these optimal physiological states would be consistent over time within an individual and would have common features across subjects; and (3) perhaps the earlier conceptions of biofeedback were too simple and that specific individual states were perhaps important factors in determining the significance of the biofeedback for any one individual. That is, the problems of individual response specificity may have to be given more attention. This was felt to be particularly true for alpha regulation, and Dr. Martin Orne stressed this point in the discussion period and in his progress report.

With respect to factor (1), there is general agreement that the original idea that specific physiological states could be defined which would be significantly related to effective performance was too simple. It appears that even within a single subject, effective performance can be maintained in varying physiological states and, indeed, that the internal state should probably vary depending upon the requirements of the particular subject and the particular task. Thus, to assume that a high heart rate or a low heart rate would significantly increase performance level or that a particular amount of alpha would always be associated with more efficient cognitive functioning does not seem tenable. It was also felt to be highly unlikely that there would be an identified physiological state consistent with effective performance that would be consistent over all individuals. Thus, the goals of many of the researchers to find physiological correlates of effective performance will probably not be successful when taken across individuals, even if a particular correlate could be identified within a single individual.

As indicated above, Dr. Orne spent some time discussing "a reconceptualization of the alpha feedback training phenomena." His position is that alpha feedback training can only help subjects to overcome influences in the external or internal environment, which are responsible for decreasing alpha density below the individual's inherent optimal level. The effect of alpha feedback training is likely to be demonstrated only under conditions where a suboptimal initial level is obtained. An example of this mechanism is training subjects to increase alpha densities in the presence vs. the absence of ambient light. Alpha feedback phenomenon thus teaches an individual to increase his alpha density only under circumstances which normally cause it to decrease and, therefore, represents a kind of disinhibition. Dr. Orne went on to state that it was his belief that a variety of mechanisms could be responsible for alpha blocking. He felt there was little reason to assume that learning to disregard the alpha blocking effects of visual interference per se should lead to the same kinds of subjective consequences as learning to disregard and prevent the alpha blocking effects by novelty or anxiety. Subjects trained to overcome blocking of alpha by anxiety mechanisms would perhaps produce more subjective feelings of relief and satisfaction than alpha training in subjects whose goals were to overcome the disruptive effect of ambient light or other distracting external stimuli. Based upon his own data, he said that it appears that the subject's ability to recover from any one of the several different blocking factors is not necessarily related to recovery from others. The discrepant findings of a number of investigators studying the alpha feedback phenomenon, Dr. Orne felt, could be understood by recognizing that alpha augmentation depends upon learning to ignore or disregard the particular mechanism which is responsible for decreasing alpha density in a particular situation.

The consequence of alpha feedback training for subjective experience and probably performance, therefore, will depend upon the nature of the specific mechanism that is responsible for blocking alpha activity. The meaning of both alpha blocking and its suppression with feedback will depend largely upon the mechanism originally responsible for dropping alpha density below its optimal baseline.

The consensus of the discussion during the second day was that the direction of the research should, in most studies, be modified. Attempts to identify optimal physiological indices or optimal physiological levels in specific measures, e.g., alpha, heart rate, blood pressure, muscle, etc., that would be related to effective performance, should be discontinued and new studies be designed where self-regulation would be used to re-establish a physiological state that had been severely disrupted, either by pain, anxiety, external stress, fatigue, sleep loss, or other such disruptive factors. If self-regulation were to be of value in maintaining human effectiveness, it would probably be in the area of helping the subject to maintain an acceptable internal state in the face of severe stress, sleep loss, fatigue, etc., or to help return the subject to acceptable physiological levels rather than in the establishing of a particular alpha pattern, EEG coherence pattern, heart rate, or level of muscle tension in a normal state.

The problem of performance tasks was also discussed with particular emphasis on the applicability of most laboratory-type tests to field situations. The pros and cons of this problem were discussed and, as in the past, no resolution was achieved. There was, however, general agreement that some assistance was needed in this area, particularly with the goal of making more comparable the performance measures collected in the various laboratories.

ARPA SELF-REGULATION REVIEW PANEL MEETING

This meeting was held the day following the ARPA Self-Regulation Symposium. At their November 1971 meeting, the panel recommended that Dr. Melzack be replaced by Dr. Martin Orne as a member of the panel. This suggestion was in line with the policy that the subcontractor member of the panel be rotated each year to insure that viewpoints from the various subcontractors will be available to the panel. Dr. Austin Kibler attended this meeting, and, when asked to evaluate the program in terms of its potential use at this point, he stated that while the ultimate findings were still uncertain, it appeared that if self-regulation was to be useful, it would probably be limited to specific personnel assigned to unique tasks. It did not appear feasible at this time to anticipate that self-regulation would be a technique that would be generally applied to large groups of men in routine tasks even though these may often be stressful.

The panel members discussed at length the fact that some of the subcontractors were not yet approaching the goal of relating their particular measure to performance. The panel recommended that a letter be written to each of the subcontractors, stressing again the importance of achieving this goal and that the current year's support, in many instances, would be a terminal year unless positive results were presented. To assist in the area of performance testing, it was recommended that a consultant be appointed to work with each of the individual subcontractors in this area. Subsequent to this meeting, Dr. Lawrence has asked Dr. Earl Alluisi, University of Louisville, to serve in this capacity, and he has agreed to do so.

How to best use the capabilities of laboratories such as those represented by the Human Factors Research, Inc., and American Institutes for Research, or Bolt Beranek and Newman Inc. was also discussed. It was hoped that these more applied research laboratories would be interested in submitting proposals to explore some of the basic research findings reported by the subcontractors. Since the meeting, Dr. O'Hanlon of the Human Factors Research, Inc., has submitted a proposal to collaborate with Dr. Jack Beatty at UCLA to determine if self-regulated EEG activity could be used to minimize the usual decrement found in operator performance in a simulated air surveillance radar system, and this proposal will be funded.

The panel agreed to meet toward the end of 1972 to again review the program at that time.

SUMMARY OF RESEARCH BY INDIVIDUAL SUBCONTRACTORS

As in the past progress reports, the summary of the work done by individual subcontractors will be divided into specific areas: I. Brain Activity; II. Sleep Induction; III. Auto-Regulation of Vasomotor Tone; IV. Cardiovascular Studies; and V. Control of Pain.

I. Brain Activity

The three subcontractors concerned with self-regulation of alpha activity are Dr. Joe Kamiya, Langley Porter Neuropsychiatric Institute, Drs. Martin Orne and Dave Paskewitz, Institute of Pennsylvania Hospital, Philadelphia, and Dr. Jack Beatty, University of California at Los Angeles. Drs. Jan Berkhout and Don Walter, University of California at Los Angeles, and Dr. Gary Galbraith, University of Southern California, are concerned with the relationship of EEG coherence patterns to performance and the ability of the subject to regulate EEG activity over the scalp.

The three investigators concerned with self-regulation of alpha activity have all attempted, during the past year, to relate the ability to control EEG activity to performance. In each instance, the results have been negative.

Kamiya:

Dr. Kamiya has studied tachistoscopic acuity to determine whether EEG parameters in untrained subjects would show a natural temporal covariation with ability to detect particular patterns presented by visual tachistoscopic techniques. The subject was to determine whether a letter B or F appeared in a 4x4 array of letters. The EEG and performance data were recorded on analog magnetic tape and analyzed by the PDP-15 computer. Power spectra, based on a Fourier transform of 128 sample points, were computed for each of the four channels based upon 1 sec. of data. The results were uniformly negative. The evoked potentials failed to differentiate correctness of response, the motor response, or the stimulus type. Power spectra at each of three time periods, a 1 sec. period after the stimulus, a 1 sec. period immediately preceding the stimulus, and a 1 sec. period lasting from the second to the first second before the stimulus failed to show any systematic relationship with performance. Similar negative results were found in a study attempting to relate the EEG to memory for words. This study was guided by the hypothesis that the naturally occurring fluctuations in the power of the EEG had specific frequencies, obtained in the course of presentations of a word memory test which would be related to fluctuations in performance on the memory test.

Twelve young adult subjects were used in this study. The EEG and their response data were again recorded and later analyzed by computer. Mean power spectra were obtained for each of four types of responses for the trials; false alarms, misses, correct rejections, and correct hits. A hit occurred where a stimulus presented for the second time was classified by the subject as "old." Visual inspection of the four power spectral plots for each of the subjects revealed no noticeable differences. The same was true when the spectra were examined for individual frequencies. The tentative conclusion by Dr. Kamiya was that the EEG, at least as examined by the methods of the above two studies, does not distinguish errors of omission or comission in a test of verbal recognition memory, nor does the EEG distinguish correct rejections from hits in this task. Dr. Kamiya, however, felt that the negative conclusions must be tentative because of several limitations of the study. One important limitation is that the study was based only on the 1 sec. interval before and the 1 sec. interval after the stimulus. A second limitation is that statistical testing for differences among the response classes was not done. A third limitation is that the range of variations of attentional vigilance in this study was small; the test being quite compressed in time. In light of the absence of a relationship between the EEG and verbal memory performance in this study, however, Dr. Kamiya felt that a study of the effect of self-regulation of specific EEG patterns does not yet seem indicated.

In another study, Dr. Kamiya attempted to determine whether subjects trained to control alpha amplitude would show improvement in performance tasks if break periods from the tasks were used to maintain high alpha amplitude. The reasoning underlying this hypothesis was that alpha is often regarded as indicative of a resting or idling condition which may be characteristic of rest periods from performance tasks. Five young male adults were given a battery of performance tasks with 4-minute break periods between each task. The control group was told to merely wait for four minutes between tasks while the experimental group was trained to produce alpha and had four minutes of alpha feedback between tasks. The tasks were verbal auditory vigilance, rod and frame, Guilford creative intelligence, visual memory, mental arithmetic, digit memory span, and tone tracking. The results were negative. The conclusion was that the self-regulated high alpha break period did not facilitate task performance.

A study concluded earlier, concerned with EEG and reaction time, was also negative. There was no consistent frequency showing the best prediction of reaction time. The results were negative for both the occipital as well as the central electrode placements.

In a further attempt to find a relationship between EEG activity and performance, Dr. Kamiya is preparing a study which involves the presentation of a changing stimulus, the task being that of manually operating a control device to follow stimulus changes as closely as possible. This, essentially, is an auditory and visual tracking task. Deviations from correct tracking will be continuously monitored by the computer. Following an earlier observation that left-right dominance of power in EEG "telegraphs deviations" from tracking, an attempt will be made to see if an improvement in performance would result if the subject is given a warning stimulus whenever the EEG shows hemisphere dominance changes predictive of errors. If performance improves, the next question will be whether the improvement sustains itself without the warning; i.e., whether there is learning. The hardware and software for this experiment are nearly completed, and pilot runs will be started soon.

More attention has also been given to the mathematical considerations of EEG analysis, and a hidden line display for continuous

EEG spectra has been developed. This will permit display in rapid succession a sequence of frequency spectra of EEG signals obtained directly from the subject or from analog FM recordings. The program package samples the signal for 1 sec., a period of time over which the spectrum is usually stable, computes the power spectrum, performs log transformations, and produces a video plot on a storage scope screen. This process is repeated each 1/2 sec. to give a smoothed succession of plots. The purpose of this display is to condense the largest possible volume of data which can be rapidly scanned and interpreted by the experimenter.

Orne & Paskewitz:

In previous progress reports, Dr. Orne and his group clearly indicated that (1) there is a high correlation between the subject's ability to carry out cognitive tasks and the extent of alpha blocking observed; (2) that there is a gradual decrease over time in alpha blocking with difficult tasks. The data presently available, however, were not adequate to establish whether this effect can be ascribed to alpha feedback training; and (3) little, if any, alpha augmentation can be demonstrated over six feedback training sessions carried out in total darkness.

The earlier work by this group indicated that when given a complex task, subjects trained in alpha control did not continue to produce alpha but, instead, showed consistent alpha blocking. This phenomenon has been known for many many years and, thus, was hardly a new finding. The results of these early studies, however, tend to support the general conclusions being reached in other laboratories, that in most subjects complex cognitive functioning is incompatible with high levels of alpha activity.

Much of the work during the past year has been directed toward developing a technique for studying the relation of alpha feedback to stress. The results of these studies to date have been negative. The initial studies used heat stimulus as a stress. The intensity of the heat was to be controlled by the subject by means of a lever-pressing procedure; the subject could control the intensity of the heat by the rate with which he pressed the lever. The rate of lever pressing was initially viewed as a measure of anxiety, and the question to be explored was whether the ability to self-regulate alpha activity would reduce the degree of anxiety associated with this potentially stressful situation. If the anxiety was controlled, the subject would maintain a more fixed and moderate rate of lever pressing. If anxiety was not controlled, the rate of lever pressing would increase as the subject became more anxious. For many reasons, too numerous to detail in this summary, despite its initial appeal, the lever-pressing procedure was found not to be suitable and Dr. Orne and his staff were not able to adapt it to their experimental problem.

In line with Dr. Orne's current conceptualization that alpha feedback phenomena can only be understood by recognizing that alpha augmentation depends upon learning to ignore or disregard the particular mechanisms which are responsible for decreasing alpha density in a particular situation, his laboratory will be concerned with re-evaluating feedback in the context of stress and in the context of drowsiness to determine the extent to which training may prevent negative effects on performance. Training procedures will be undertaken to select specific subjects. Dr. Orne feels that comparison between the effects of alpha feedback training on subjects who are selected for their ability to do this successfully vs. individuals who are selected for their inability to do so will clarify the possible contribution of the procedure as opposed to the actual learning of the procedure by the subject. A stress procedure will be developed, and the goal of this study will be to see if subjects can be taught to prevent alpha blocking under conditions of stress. Their ability to use similar techniques without feedback will be tested in a subsequent session. Performance measures will be used to establish the effect of feedback training in decreasing the negative effects of stress. The performance measure being considered is one which requires the subject to correctly press one of several keys in response to one of several spoken numbers. The rate of presentations will be varied to allow the task to be speeded up to the point of stress. Incorrect responses will lead to shock or other adversive stimulation. Comparisons of performance before and after training by good and poor alpha enhancers will be made.

The second study concerns the relationship of alpha density and vigilance. From Dr. Orne's point of view, drowsiness may be conceptualized as yet another alpha blocking mechanism which feedback training may help the subject to overcome. In this study, subjects will be partially deprived of sleep to see if training to augment alpha activity by tired subjects may not produce results significantly different from maneuvers such as pinching themselves, sitting up, etc., that many tired individuals employ to remain alert. It is hoped that alpha feedback training may teach an individual strategies which will allow him to resist the effect of sleep loss and maintain a passively alert state of mind. Both of these studies are to be undertaken during the next fiscal year.

Beatty:

Dr. Beatty has studied the effects of occipital synchrony, or alpha feedback, on processing visual information. In this study, two measures of information processing capacity were utilized; short-term memory for digits and choice reaction times. The five best alpha-producing subjects were used in the short-term memory study. Occipital alpha was monitored, and the subjects were trained to either self-regulate alpha or beta activity. The entire experiment was conducted under digital computer control. Crucial to the assessment of the effects of auto-regulated EEG states on information processing was the determination that the desired state was reached before the task was presented. On-line computer scanning of the EEG was employed preceding the delivery of information to the subject on each trial. Each trial was begun by an instruction for the subject to produce either a high alpha state or a beta state. A computer then began the process of sampling the EEG and measuring one wave each second to determine its period. When the desired EEG pattern was maintained for 3 secs., the digits were presented. The experiment was partitioned into blocks of 10 trials. In each block, a single cortical response-type alpha or beta was used. The number of digits in each string was set to produce error rates as close as possible to 50 percent. The number of digits was adjusted up or down, depending upon the subject's performance. The number of strings presented at each length was the same for the alpha and beta conditions.

The data indicate that there was essentially no detectable difference in the efficiency with which most of the subjects process symbol strings when those strings are presented in periods of occipital alpha or beta frequency activity. Dr. Beatty felt that one explanation of these negative findings might be that regardless of EEG state, when the digit string was presented, the subject quickly blocked ongoing alpha or maintained ongoing beta as he performed the short-term memory task. Thus, the information was delivered to different brain states between conditions, but the information was processed in one brain state in all conditions, occipital desynchrony.

In the choice reaction time, the subject watched for a signal on a screen and, when it appeared, he was to depress a button indicating its identity. He was to perform the task as quickly and as accurately as possible. Since the process of detection, decision, and response was over in between .3 and .6 secs. for most subjects, this task was felt to be more dependent on the state of the brain synchrony at the time of stimulus presentation than in the previous digit memory task. Dr. Beatty felt that if cortical synchrony is related to information processing efficiency, then it should show its effect in the choice reaction time task. This study was again under computer control, and when the necessary EEG state had been maintained for 2 secs., the stimulus was presented. Three of Dr. Beatty's five subjects showed consistently shorter reaction times when the stimulus occurred during desynchrony than in synchrony. While Dr. Beatty felt these results were encouraging, three out of five subjects is not a significant difference so that, until more data are obtained, it is not possible to state whether there is evidence that auto-regulated EEG states can alter the efficiency with which the human brain processes information. The results, however, are compatible with previous findings that the state of desynchrony, long associated with high arousal, facilitates the handling of information in subjects.

While the results of these three studies are essentially negative with respect to behavior and performance, information as to the conditions under which alpha occurs or does not occur has not been as consistent or uniform from all three laboratories. As indicated earlier, Dr. Orne feels that alpha enhancement is basically learning to overcome inhibition and that the type of inhibition varies from study to study and from individual to individual. Dr. Kamiya does not completely support this inhibitory hypothesis and has presented data to indicate that trained self-regulation of EEG alpha does result in the subject's learning a new skill. Dr. Beatty has found that subjects learn to control occipital alpha and beta activity with equal ease in the dark and in the light, which he offers as contradictory data to that reported by Drs. Orne and Paskewitz. Dr. Beatty has also found that the EEG generating system is relatively independent of the brain systems controlling respiration and heart functions in man; also, that human subjects may learn to produce occipital synchrony or desynchrony to avoid unpleasant stimuli as well as to receive more pleasant reinforcement.

In discussing the differences in findings among the laboratories, Dr. Kamiya suggested that perhaps the method of measurement of alpha might be one factor contributing to the differences and, second, that the method of providing feedback could be a factor. How, and by what means, a subject regulates his brain activity is clearly an area with differing explanations and mixed results. The only consistent finding of the three subcontractors is that self-regulation of EEG activity has not been found to be effective in enhancing human performance in the tasks they have studied to date.

Berkhout & Walter:

Drs. Berkhout and Walter, during the first year of their study, have been concerned primarily with acquisition of neurophysiological data concurrent with performance during stressful and demanding tasks. They have selected three performance situations for intensive analysis, and these range in complexity from auditory flutter-fusion test of perceptual acuity through a multi-limb visual-motor coordination task (involving a device known as a complex coordinator) to a high-speed driving task involving operation of an automobile on a closed track under genuinely dangerous and stressful conditions. Data acquisition has been completed under all three conditions, and they are proceeding with the correlation of neuroelectrical patterns and various parameters of task performance. Attempts will be made to identify EEG intensity and coherence components with various measures obtained during the tasks. The main interest will be on coherence; e.g., the shared activity of the brain from two recording sites.

The second phase of their investigation concerns self-regulation of coherence parameters in an experimental environment, utilizing visual coherence displays. Their initial experimental sessions were devoted to a survey of the possibility of establishing volitional control over coherence levels between various electrode derivations, at various frequencies, and with the various display constants and rates to be used in updating this information. Eight subjects have been surveyed in sessions lasting from one to two hours. All sessions were permanently recorded on both paper chart and digital format for subsequent off-line evaluation and review. Alpha-range coherence was found to be most amenable to volitional control in a parietal-occipital derivation. Coherence in this derivation was highly correlated with gross alpha activity, and the traditional strategies for global alpha enhancement and blocking affected coherence values in a similar way. Coherence at 14 Hz was reported "controllable" to various degrees by three of the six subjects, with a reduction in coherence in the parietal-occipital channels being easiest to obtain. Subjects reported that various strategies of mental imagery, imagined stress, and other subjective means of "keeping the mind going" seemed to influence the display, but that complete point-to-point control over display excursions was impossible to attain.

In subsequent studies, a reaction time task will be used in which the presentation of stimuli will be triggered by excursions both above and below fixed thresholds of coherence at 14 Hz. Significant differences in the two sets of reaction times generated this way would serve to confirm the hypothesis that 14 Hz coherence levels are, in fact, closely related to the functional levels of arousal. It is presently unclear whether such continuous fluctuations, in fact, reflect a rapidly shifting level of alertness or whether the rates of fluctuation themselves are correlated with functional arousal states of longer duration.

Galbraith:

Dr. Gary Galbraith at the University of Southern California has also found that certain subjects can control EEG coherence values. Such control was found to be manifested in two ways; by a voluntary shift in level of frequency or coherence above or below baseline, and by a change in moment-to-moment patterns of variabilities as compared with baseline. In Dr. Galbraith's study, the subject is free to select feedback from one of ten possible combinations dealing with four electrode placements or the combination of placements. The graphic computer displays a head outline which depicts the various electrode combinations. EEG mean frequencies can be selected for feedback in all of the 10 cases, but coherence can be selected for feedback only in the cross-spectral combinations. Once a button is selected, the computer samples and computes spectra during a 2-minute baseline. Following the baseline determination, the results are displayed. During the 5-minute feedback session, the subject is able to view either the EEG frequency or coherence for the selected electrode combination. During the feedback session, the subject decides whether to maintain a specific EEG frequency pattern from a single electrode position, or, if he selects an electrode combination, he attempts to maintain high coherence of activity between these two electrodes. In a task concerned with verbal learning, Dr. Galbraith has found that coherence patterns for correct responses tend to differ from those patterns when the response is incorrect. In a subject with 80 percent accuracy, there was a tight clustering of coherence values, while a subject with only 20 percent correct responses showed great variability of coherence values. In general, correct trials showed less variability of coherence than incorrect trials. Dr. Galbraith feels that these findings suggest that coherence patterns may provide information concerning state dependent events within the central nervous system during learning. While a specific pattern appears to be consistent over trials within a single subject, the patterns varied considerably from subject to subject. Thirteen subjects have been run to date in the verbal learning experiment, and Dr. Galbraith plans to add an additional 25 to 30 subjects to examine inter-individual consistency in coherence patterns associated with correct and incorrect responses.

To study the relationship between performance on this task and ability to control coherence during biofeedback, the best and worst subjects, based upon performance in the verbal recognition test, will be selected for biofeedback training. It is Dr. Galbraith's hypothesis that those subjects who perform well on the verbal recognition tasks will be able to exert greater control over their EEG patterns.

II. Sleep Induction Studies

Dr. Wilse Webb and Bob Agnew, University of Florida, and Drs. Johann Stoyva and Tom Budzynski, University of Colorado, are the two subcontractors working in this area. Dr. Webb and his colleagues have selected three aspects of the sleep response for detailed study: (1) the onset of sleep, (2) chronic control of the length of sleep, and (3) control of effects of loss of sleep.

(1) Control of sleep onset. Here, the efforts were confined to and directed toward attempts to control sleep onset by control of auditory stimulus input. Eight subjects have been run in this study under 12 experimental conditions. These conditions included a period of silence, during presentation of a continuous tone, during exposure to an intermittent tone (15 tones per min.); a counting with the tone; and closing one's eyes with the tone. In a second experimental series, six subjects were run in a balanced design involving three tone rates (5, 15, and 30 tones per min.) with periods that involved tone alone, tone counting, and breathing with

a tone. In general, sleep induction by tones, regardless of method of presentation, under conditions of low sleep probability (all subjects were run during the day after a full night of sleep) showed limited sleep induction effects. The shortest latency under the experimental condition was 10 mins., which is only a slight decrease from the average sleep latency of 18 mins. under a no-stimulus input situation.

(2) Control of sleep time. Eight subjects were maintained on a 5-1/2 hour sleep regime for a period of eight weeks. Each week the subject's sleep was measured in the laboratory, and performance tests were given at this time. In the first phase of the study, it was noted that one of the tasks, the auditory vigilance task, was particularly sensitive to sleep debt and showed a decrement over the 8-week period. Also, in the initial study there was a deterioration in the amount of stage 4 sleep and of waking alpha density over the 8-week period. Dr. Webb and his group are now repeating the 5-1/2 hour sleep study. In the eighth week of the present study, they find evidence that the vigilance task is beginning to show deterioration, but the deterioration of stage 4 sleep is less striking.

(3) Control of acute deprivation effects. In an attempt to determine the extent to which rest can offset the deterioration effects of sleep loss, subjects were deprived of sleep without rest for two days and, at a subsequent time, deprived of sleep but permitted to bed rest during the normal sleep period. Four subjects have been run under this design, and initial inspection of these subjects' performance indicates that bed rest does not prevent the performance decrement brought about by sleep deprivation.

During the final year of this project, Dr. Webb will complete the analysis of the control of sleep onset data and prepare final reports concerned with the control of sleep length and control of sleep deprivation effects.

Stoyva & Budzynski:

The focus of the work by Drs. Stoyva and Budzynski has been on biofeedback training in the self-induction of sleep. The main results for the past year are as follows:

(1) Shaping of the theta 4-7 Hz EEG. This study compared two training techniques for teaching subjects to produce theta: (1) Under the one-step treatment, subject received direct feedback of theta rhythms for their 8 training sessions; (2) The other training technique involved two stages. The first four sessions consisted of EMG feedback, and for the second four sessions the subjects were shifted to direct feedback of theta rhythms. A difficulty experienced by Drs. Stoyva and Budzynski in providing theta feedback was that theta frequencies were present even when the raw EEG trace shows the subject to be in alpha. This meant that the subject received some theta feedback even when he was producing mainly alpha. To solve this problem, a theta inhibit circuit was devised by Dr. Budzynski. Essentially, subjects would not receive any theta feedback except in the absence of alpha. After this improvement, subjects became much better at identifying the bodily sensations associated with theta. The confusion experienced when both alpha and theta states produced feedback was eliminated and they were able to proceed with the main experiment. Drs. Budzynski and Stoyva believe the preceding observation relates to what may develop into an important principal in feedback training; that is, information feedback indicating the correct response should be provided only

when the appropriate bodily cues are likely to be present. Thus, in the present experiment, theta feedback was provided only when alpha rhythms were absent.

The shaping of theta EEG study has just been completed. Twenty subjects between the ages of 35 and 50 were divided into four different groups: (1) high EMG subjects receiving one-step training (all theta); (2) low EMG subjects receiving one-step training (all theta); (3) high EMG subjects receiving two-step training; and (4) low EMG subjects receiving two-step training. For each of the 20 subjects, data were obtained from two baseline sessions, eight feedback sessions, and two post-baseline sessions. Each session consisted of 15 consecutive one-minute trials. Continuous measurements were taken on each of the five parameters of interest, and the digital counters provided readouts on a trial by trial basis. The five parameters were alpha EEG, theta EEG, heart rate, frontalis EMG, and forearm EMG. The results showed clearly that subjects whose baseline EMG levels were high (these are likely to be older subjects or those in demanding jobs) did better at increasing their theta levels if they were given a two-step feedback training--first, EMG feedback training, then theta feedback training. On the other hand, subjects whose starting EMG levels were low (bottom half of this sample) did equally well at producing theta with either type of training. That is, with low EMG subjects, those who were given simply the one-step training (theta feedback for all training sessions) learn to produce just as much theta as those who were given a two-step training (EMG feedback for first half of training, followed by theta feedback for second half of training).

Several other relationships emerged in this experiment: (i)

Heart rate declined significantly--a result most pronounced in the high baseline EMG groups, and (ii) Frontalis EMG levels showed marked declines, particularly in subjects with high baseline EMG levels.

Findings suggested in earlier studies have been clarified and, in many instances, confirmed during this second year. These include:

(1) Reciprocal frontalis EMG - theta relationship. This relationship, suggested as a possibility in earlier progress reports, has now been clearly documented. The reciprocal association is particularly strong at sleep onset--where stage 2 "spindling" sleep begins. At this point, and just prior to it, frontalis EMG shows a sharp drop and theta rhythms display a sharp increase.

(2) Frontalis feedback versus forearm feedback. A previous study in year 2 showed that subjects generally become relaxed not only in the muscle which is receiving feedback training, but in other muscles as well. This was especially true for the frontalis muscle; e.g., subjects receiving feedback training on the frontalis showed substantial EMG decreases both on this muscle and on their forearm extensor. However, the converse relationship was not true. Subjects receiving forearm EMG feedback showed a substantial decline in forearm EMG levels but essentially no decrease in frontalis EMG activity.

(3) High and low EMG subjects. In the above study, the individuals who showed the most dramatic drop in EMG levels were those whose muscle tension levels were comparatively high at the beginning of training. Those whose EMG levels were already low at the beginning of training showed only a moderate decline in EMG activity with feedback training--a result in keeping with the law of initial values.

The conclusion by Drs. Stoyva and Budzynski, from the foregoing observations, is that feedback training in muscle relaxation will be most useful with subjects who show high resting muscle tension levels. These are likely to be people who work in demanding or stressful situations; i.e., situations in which the individual must mobilize his resources, physical and mental, for responses which enable him to survive, or for important administrative decisions.

Individuals living under sustained stress conditions are likely to lose the ability to shift easily to a relaxed (low arousal) condition. Their recent experimental results, however, strongly indicate that muscularly tense subjects can be taught to produce a relaxed (low arousal) condition by means of EMG feedback training followed by theta feedback training.

Since they are now confident that they have evolved the main elements of a technique for reliably inducing low arousal in tense individuals, their major effort for year 3 will be to examine the effects on performance of such an ability.

III. <u>Auto-Regulation of Vasomotor Tone</u>

The principal investigator in this area is Dr. Edward Taub. Operating on the hypothesis that a rapid reacting temperature probe would provide a simple, accurate, and easily set-up means of observing and in controlling regional blood flow, Dr. Taub has, during the past two years, developed an effective technique for training and measuring the ability of subjects to self-regulate skin temperature. In his technique, one thermistor probe is placed on the dorsum of the dominant hand, while another thermistor probe is placed at another location, usually the dorsum of the other hand. A feedback light, located at eye level, is placed in front of the subject. The intensity of the light varies directly with changes in skin temperature in the dominant hand. After a baseline day, operation of the feedback light is introduced on the second day. The subject was told what the nature of the task would be; that is, to either increase or decrease the temperature of the skin and that the intensity of the light would vary as his skin temperature changed. One-half of his subjects were told to increase skin temperature, and the other half were told to decrease skin temperature in the initial feedback sessions. The subject was told to use thermal imagery to achieve auto-regulation, and, in addition to the flat fee for participating in the experiment, subjects were reinforced for changes in skin temperature in the instructed direction at the rate of $.25 for each 1/4°F. Thus, there were two different kinds of methods employed in the training procedure. First, the subjects were instructed to carry out that type of behavior normally designated as imagining. In addition, thermal responses were reinforced and shaped in operant fashion with the feedback light and, in some subjects, with its associated money reward. The training period was 15 minutes long, with no feedback during the first 2 minutes.

During the two years since the initiation of this project, Dr. Taub and his staff have developed techniques for enabling most humans to establish rapid operant control of their own skin temperature, when provided with immediate feedback information concerning variations in local skin temperature. Nineteen of their last 20 consecutive subjects have been able to learn auto-regulatory control of this parameter. Training to a level of unequivocal acquisition rarely required more than four 15-minute training periods. After that time, the mean change per 15-minute session for all subjects was approximately 2.5°F., ranging up to 6.5°F.

After the original training, some subjects were asked to reverse the direction of their auto-regulatory control, and, after further training, still more difficult experimental tasks were introduced involving complex patterns of temperature regulation within brief spans of time. Dr. Taub reports that two subjects who are currently most advanced can go in opposite directions during successive periods on the same day, and routinely display ranges of 8-15°F. within 15 minutes.

Retention of the task has been found to be virtually perfect over an interval of 4-5 months in the four cases tested to date. It was also found that, after sufficient training, auto-regulation of skin temperature was as good without feedback as with feedback.

Early in training, the temperature response tends to be anatomically diffuse, with considerable co-variation by the contralateral untrained hand. As mastery increases, the response becomes more and more localized to the trained portion of the body and eventually develops considerable anatomical precision. At this point, transfer of control to other portions of the body can be accomplished readily, and regulation in the new location is also specific.

During transfer testing, two subjects were asked to raise the temperature of their forehead. In both cases, when increases of 3-4°F. were achieved, severe headaches of rapid onset developed, leading to requests for termination of the session. This phenomenon would seem to suggest that they have succeeded in achieving a level of auto-regulatory control of tissue temperature and blood flow that is great enough to warrant testing in applied settings.

The applications phase of this project will begin in July at

The Army Institute for Environmental Research, Natick, Massachusetts, in collaboration with the Commanding Officer, COL LeeRoy Jones. An attempt will be made to reduce frost-nip and to enhance manual dexterity in very cold environments through self-regulation of hand skin temperature.

IV. Cardiovascular Studies

Dr. Leo V. DiCara, University of Michigan, and Drs. Harris, Stephens, and Brady, Johns Hopkins University, are the two groups working in this area.

DiCara:

Dr. DiCara began the work in this program on October 15, 1971, after his move from Rockefeller University to the University of Michigan. During this initial year, most of his efforts have been directed toward renovation and equipping a laboratory to be used for his human and animal studies. The renovation and installation of equipment are nearing completion, and work in the human area is planned to begin this fall. The personnel necessary to begin the work, both in the human and animal areas, have been hired.

Harris, Stephens, & Brady:

The work in this laboratory has been divided into two areas: (1) that concerned with limit testing using laboratory primates, and (2) that concerned with the control of heart rate in human subjects.

Limit testing with laboratory primates. At the beginning of this research year, a study entitled "Instrumental conditioning of blood pressure elevations in the baboon" was completed and has been published. This study reported the finding that baboons could produce 50-60 mm Hg increases in blood pressure, both systolic and diastolic, for several minutes up to 70 times during a 24-hour period. The procedure for bringing about this performance involved the contingent management of environmental events (food pellets, electric shocks, and colored lights) based upon specified criteria levels of the animal's diastolic blood pressure. This first study focused attention upon the development of acute, large magnitude cardiovascular changes for relatively short epochs.

A subsequent study investigated the effects of chronically maintained elevations of blood pressure also produced by the contingent management of food pellets and electric shocks. Following baseline determinations, the animals were required to raise their diastolic blood pressure 3-5 mm Hg in order to produce food and avoid electric shock on a schedule of five food pellets per 10 minutes above criterion level and one shock per one second that the diastolic blood pressure remained below the criterion levels. These dual contingencies were in effect continuously except for one hour each day when data were collected, when the animals were checked clinically, nutritional supplements provided, and other routine maintenance procedures carried out. After approximately three weeks on this continuous program, both animals showed signs of severe stress (e.g., weight loss and fatigue), and began to receive an excessive number of electric shocks (50 or more per day). At that point (about four weeks from the start), the experiment was discontinued and the animals permitted to rest and recover. Prior to termination of this experiment, both animals were maintaining 15-20 mm Hg elevations of blood pressure for 23 hours per day.

A third experimental procedure, currently under investigation with five baboons, requires a similar continuous maintenance of altered blood pressure levels but for periods limited to only 12 hours each day. The present procedure provides a daily 12-hour "Conditioning OFF" period during which control (rest) cardiovascular measures are available for comparison with the 12-hour "Conditioning ON" changes. Additionally, changes in the 12-hour "OFF" cardiovascular levels related to the demands of the 12-hour "ON" period are also of particular interest. The animals are restrained in specially designed primate chairs and housed in sound-resistant wooden chambers (3'x4'x5'), which serve as both the living and working quarters for the continuously programmed environment. Each baboon has been surgically implanted with a polyvinyl catheter employing an approach to the abdominal aorta via the femoral artery, with the beveled tip of the catheter passed to a position just above the bifurcation of the common iliac arteries.

Adjustable meter relays are integrated with the automatic programming equipment to permit systematic selection and variation of criteria diastolic blood pressure levels and activation of the food-reward and shock-delivery devices. One-gram food pellets are delivered through a tube from an automatic feeder mounted on top of the chamber to a tray on the work panel (also containing multiple stimulus lights, push-button switches, and a Lindsley lever manipulandum) which faces the animal in the enclosure. Shock is administered through a stainless-steel band fitted around the animal's abdomen as a waist electrode with the remaining metal portions of the chair (i.e., cuffs, seat, supports) serving as the grounded second electrode.

Following post-surgery recovery, baseline levels for systolic blood pressure, diastolic blood pressure, and heart rate were established over a two to three-week period, and after baseline determinations, all animals were introduced to the conditioning program: Animals 1, 2, and 3 were rewarded for raising diastolic blood pressure, and Animals 4 and 5 were similarly rewarded for lowering diastolic blood pressure levels. Additionally, all animals were punished with electric shock for diastolic blood pressure changes in the opposite direction, and could only avoid electric shock by maintaining the diastolic blood pressure levels required by the indicated program.

For both experimental groups, the conditioning program was in effect 12 hours per day from noon to midnight. For the 12-hour period from midnight to noon, the conditioning program was off. During the 12-hour "Conditioning ON" period, all three animals produced elevations of blood pressure necessary for procuring food and avoiding electric shock. The animals generally maintained mean diastolic blood pressure levels about 5 mm Hg above the specified criteria levels. This blood pressure elevation was progressively increased during the experiment until the diastolic blood pressure reached the 110 mm Hg stabilization level. This level was achieved after approximately six months of training for Animal 1, four months for Animal 2, and three months for Animal 3.

In response to the demands of the 12-hour "Conditioning ON" program, all three subjects produced 30 to 40 mm Hg increases in both systolic and diastolic blood pressure, and maintained that elevated level continuously for 12 hours per day, seven days a week, for several months. While pressure was maintained at relatively constant levels, heart rate tended to show progressive decreases both within and across experimental sessions.

As training in the 12-hour "Conditioning ON" performance continued, the daily pattern that emerged was one of gradual improvement of performance as the 12-hour "Conditioning ON" interval continued until the increased cardiovascular levels began to "spill over" into the 12-hour "Conditioning OFF" period. At midnight, when the "Conditioning ON" program went off (i.e., all feedback lights suddenly terminated), blood pressure and heart rate both dropped rapidly at first and then more slowly with heart rate reverting less rapidly to asymtotic levels. As training continued, the "Conditioning OFF" blood pressure began to increase progressively until the 12-hour "OFF" blood pressure was regularly 20 to 30 mm Hg above the initial baseline values. In order to determine the stability of the elevated 12-hour "Conditioning OFF" pressures, baseline conditions were reinstated. In all three subjects, the elevated "OFF" pressures continued for weeks and sometimes months before gradually subsiding to the initial baseline values.

In the decrease group, cardiovascular levels increased but, as training continued, cardiovascular levels gradually returned to and eventually fell 5 to 10 mm Hg below the initial baseline level. Subsequent redeterminations of baseline did not recover the higher initial baseline values, but, rather, the 5 to 10 mm Hg lowered values attained during the conditioning program, indicating perhaps an overall decline in cardiovascular level as long-term adaptation to the general laboratory environment transpired. The conditioning program could well have been instrumental in initiating or enhancing this adaptation process, however. At the very least, these two animals in the "lowering" group serve as powerful controls for the effects shown in the blood pressure "increase" group. The low (baseline) cardiovascular levels maintained throughout the experimental months for the two animals in the "lowering" group occurred under the same conditions that prevailed for the blood pressure "increase" group, thereby providing a control for the effects of (1) electric shocks, (2) food and food deprivation, (3) surgery and catheterization maintenance, (4) confinement and restraint, and (5) the laboratory setting in general.

Performance interactions and autonomic self-regulation in humans. Research by Drs. Harris, Stephens, and Brady in progress with human subjects is concerned with the interaction between self-regulation of heart rate and performance on concurrent work tasks. Paid volunteer subjects are instructed to attempt to control (either raise or lower) their heart rate when given the appropriate signal instructions. Following attainment of heart rate control criteria, the subjects are tested on a variety of performance tasks during periods of heart rate increase, heart rate decrease, and rest.

The results of these human studies have been evaluated with respect to the two-way interaction that is established, specifically (1) to what extent does engaging in the concurrent task modify self-regulatory ability, and (2) to what extent does autonomic self-regulation of heart rate affect the concurrent task performance. Over the entire group of 19 subjects, self-regulated heart rate increases average 15 beats per minute and decreases average 5 beats per minute, with a range from 29 BPM increase to 16 BPM decrease. The main conclusions to be drawn from the data suggest that heart rate can be controlled to some extent by practically all subjects tested, and that heart rate increases are significantly easier to achieve than heart rate decreases. In addition to the indicated heart rate data, significant correlations between changes in heart rate and blood pressure have been observed, with the relationships appearing more strongly during the heart rate "increase" condition than during the heart rate "decrease" condition.

Subjects have, thus far, been tested on three kinds of tasks ranging from a relatively simple auditory reaction time requirement and a Mackworth Clock Vigilance test, to a mental arithmetic problem task under time-limit conditions. In all cases, the task requirement has been introduced repeatedly throughout each of the self-regulation components (i.e., heart rate "raising," "lowering," and "rest") with concurrent problem presentations occurring on the average of approximately once per minute with a variable interval range from 15 to 95 seconds. The interaction between the auditory reaction time task and heart rate self-regulation was studied with 4 subjects during a total of 32 experimental sessions. The results of these tests showed that all subjects were able to perform satisfactorily on the reaction time task without interfering with heart rate self-regulation and that no significant differences in the reaction time performance could be discerned as a function of the self-regulatory heart rate change (i.e., "raising" or "lowering").

The Mackworth Clock Vigilance Task required the subject to report the occurrence of skipped steps ("jumps") in the clockwise rotation of the sweep-hand on a large clock face. The vigil was maintained continuously throughout the experimental session with "clock jumps" programmed to occur on the average of once per minute during all three phases of the self-regulatory program (i.e., heart rate "raising," "lowering," and "rest interval"). The interaction between the Mackworth Clock Vigilance Task and heart rate self-regulation was studied with 4 subjects during a total of 20 experimental sessions under both incentive (i.e., special performance effectiveness "pay") and non-incentive conditions. The results again showed no discernible effect either of the concurrent vigilance task upon heart rate self-regulation or of the self-regulation requirement upon the vigilance behavior.

Research currently in progress with human subjects focuses upon the study of interaction effects between heart rate self-regulation and the performance of a mental arithmetic task involving a greater degree of complexity and "cognitive" stress.

Personality inventory evaluations have been performed on 36 of the 40 human subjects thus far participating in this study. Scores on the Minnesota Multiphasic Personality Inventory and the 16PF test have been correlated with the observed changes in heart rate and blood pressure. Two of the indicated scales (MMPI [A] and 16PF [Q4]), both standardized as measures of "anxiety," reflect relatively strong negative correlations with heart rate and blood pressure increases.

V. Auto-Control of Pain

Dr. Ron Melzack of McGill University is investigating the possibility of using self-regulation, particularly alpha feedback training, as a method to provide an effective technique for the self-regulation of pain. Dr. Melzack feels that at least four variables can contribute to pain relief in the alpha training procedure: (1) distraction of attention from painful body site to a particular inter-feeling state and to a feedback signal during training that goes on and off repeatedly and is attention demanding, (2) strong suggestions that the procedure will effectively diminish pain, (3) the relaxation that accompanies the alpha state produces a general decrease in arousal inputs, as well as a decrease in anxiety, and (4) the development of a sense of control over pain is known to diminish pain. Dr. Melzack's strategy is to utilize all of these variables in combinations, including relaxation, suggestion, hypnotic instruction, and alpha feedback. After he has demonstrated the major effects of pain relief, attempts will be made by testing other groups to determine the relative contribution of each of the four variables listed above.

The procedural steps presently being employed to achieve self-regulation of pain include a questionnaire developed to get some quantitative measure of pain intensity, a period of initial instructions, baseline EEG recordings, and some hypnotic-type instructions which will help teach the patient techniques of self-relaxation to increase his motivation to control his pain, and to create a state of greater receptivity to suggestions. These instructions will be delivered by someone who is competent in the hypnotic procedure. After the hypnotic instructions, the subjects will be given instructions for alpha training and then 20 minutes of alpha feedback training.

One of the interesting aspects of Dr. Melzack's procedure is that the subject is told he will hear music when he produces alpha, and his aim should be to produce as much alpha and thus music feedback as he can. The music feedback consists of Mozart flute music which has been rearranged with a slight jazz beat. The use of music as a feedback stimulus has been found to be particularly effective with these patients. The patients appear to become completely absorbed by it. In addition to the music, he is informed as to his success in maintaining a high alpha percent after each 5-minute period during the 20-minute training session.

Two groups of subjects have been used by Dr. Melzack; (1) clinical patients suffering chronic pain, and (2) student volunteers. The clinical patients have suffered chronic back pain for several years and their pain has persisted despite surgery, psychiatric help, or one or more standard physiotherapeutic methods. The student volunteers were normal healthy subjects.

With the student subjects, an experimental pain is induced by a pressure cuff which has small plastic pyramids sewn into it. The cuff is placed around the upper arm and is inflated at a constant rate. Two kinds of measures can be obtained: (1) the duration of pain tolerance during slow-inflation of the cup, and (2) changes in perceived intensity after the cup is inflated to a pain level that is intense but bearable. The subject is able to stop the pain at any time by simply lifting a finger to release a pressure valve.

Dr. Melzack reports dramatic relief of pain in three patients with chronic back pain. The patients appear much calmer, visibly happier, and less anxious after the training procedures. Pain intensity noted on the questionnaire reflects a striking diminution of pain. The pain relief afforded by a single session may last for several hours; even as long as several days.

One patient reports that she has cut down her intake of analgesics by more than 50 percent. Furthermore, when the pain returned during the middle of the night after several training sessions and awakened her, she played the cassette tape of the hypnotic procedure to induce the alpha state, and the pain diminished and she fell asleep.

In a similar manner, the subjects who received experimental pain similarly reported significant changes in perceived pain intensity after training, compared with scores obtained before training, and were able to tolerate the pain for longer periods of time.

Since only a relatively small number of patients and subjects can be trained at any time, Dr. Melzack plans to establish a second laboratory unit this summer. Personality and anxiety tests will be administered to patients undergoing training. To help determine which of the four variables mentioned above are most importnat in terms of pain relief, the procedure outlined above will be modified somewhat in subsequent testing. The procedure will be parcelated in order to (1) provide a shorter session (the total procedure per session at present takes more than two hours), and (2) to determine the relative contribution of the hypnotic procedure and alpha training in the control of pain. Dr. Melzack feels it is possible that both procedures together may have a more powerful effect than either one alone, but it is importnat, as a part of the research program, to determine the relative effectiveness of the two procedures alone as well as the two together.

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Appendix 1

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Robert W. Smith	American Institutes for Research, Pittsburgh
Joseph Stephens	Johns Hopkins University School of Medicine, Baltimore
Jim Stokes	Army Research Institute of Environmental Medicine, Natick
Johann Stoyva	University of Colorado Medical Center, Denver
Edward Taub	Institute for Behavioral Research, Inc., Silver Spring, MD
Gilbert C. Tolhurst	University of Massachusetts, Amherst
Richard E. Townsend	Navy Medical Neuropsychiatric Research Unit
Thomas J. Triggs	Bolt Beranek and Newman, Inc., Cambridge
Donald O. Walter	Brain Research Institute, University of California, Los Angeles
Wilse B. Webb	University of Florida, Gainesville
Walter L. Wilkins	Navy Medical Neuropsychiatric Research Unit
Donald P. Woodward	Office of Naval Research, Arlington

SCHEDULE

SECOND ANNUAL ARPA SELF-REGULATION SYMPOSIUM
MAY 19-20, 1972
ROYAL INN AT THE WHARF, SAN DIEGO

Friday, May 19 - Harbor Room

8:30 - General comments and administrative report

George Lawrence
Don Woodward
Verne Johnson
Mike Lewis
Mimi Dvorak

9:00 - Dave Hord & Dick Townsend

9:45 - Coffee break

10:15 - Martin Orne

11:00 - Joe Kamiya

11:45 - Jackson Beatty

12:30 - No host lunch

2:00 - Jan Berkhout & Don Walter

2:45 - Gary Galbraith

3:30 - Coffee - Coke break

4:00 - Johann Stoyva & Tom Budzynski

Saturday, May 20 - Harbor Room

9:00 - Wilse Webb & Bob Agnew

9:45 - Ron Melzack

10:30 - Coffee break

11:00 - Ed Taub

11:45 - Leo DiCara

12:30 - Lunch

2:00 - Alan Harris & Joe Brady

2:45 - Craig Fields

3:30 - Coffee - Coke break

4:00 - Gary Schwartz

4:45 - General discussion

Sunday, May 21 - Capt. #2

9:00-12:00 - ARPA Review Panel meeting