Incongruity, Incongruity Resolution, and Mental States:

The Measure and Modification of Situational Awareness and Control

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Incongruity, Incongruity Resolution, and Mental States: The Measure and Modification of Situational Awareness and Control

"Situational awareness" has received a variety of definitions. Endsley (1988) describes it conceptually as "the pilot's internal model of the world around him at any point in time." Adams and Pew (1989) define it behaviorally as the "moment by moment ability to monitor and understand the state of the aircraft, its systems, and its environment." A more specific description by Nagel (1988) includes the following dimensions of situational awareness:

> "the pilot must maintain awareness, for example, of where the airplane is geographically, what its current performance state is, its altitude, power setting, configuration, and relationship to other aircraft. The pilot must (1) be mindful of verbal communications and instructions from air traffic control personnel, (2) be aware of the environment, and (3) systematically monitor for and anticipate changes in weather that might affect his or her performance and that of the aircraft. Information to maintain an appropriate awareness of the

> flight situation is obtained visually, through the windows of the aircraft and from instruments, aurally from other crew members within the cockpit and from air traffic controllers over radio channels, and through the vestibular senses."

Knowledge of the past, the present, and extrapolations into the future are the fundamental capacities necessary for situational awareness. Sarter and Woods (1991), quoting Endsley, have called attention to three levels of situational awareness assessment: Level I represents the perception of situational elements. Level I requires a minimum of knowledge and expertise. Level II entails information integration. Here the participant uses past experience and strategies to control the selection and use of elements and relations in the situation. Level III involves projection of future status and actions of situational elements. The task here is to solve problems, preferably before they arise. Sarter and Woods see Level I as the main component of "situational awareness" and therefore too general to be applied to the specific problems of safe operation of an aircraft.

On the other hand, many investigators argue that such basic knowledge is necessary for a complete understanding of situational awareness and the ultimate

management of that situation (Adams & Pew, 1989; Regal, Rogers, & Boucek, 1988). Complete understanding of the human component in any situation demands the study of the individual in separate aspects of the task as well as the examination of how it is all put together as a whole. From this multidimensional and converging approach, the specific importance and relative contribution of all features of situational awareness and control can be determined. These capacities of awareness and control are the foundation of a basic cognitive skill known as pattern recognition (Farell, 1985). Consequently, a clear understanding of more complex activities will depend on the evaluation of factors that contribute to and disrupt pattern recognition of all kinds.

In order to study these factors and generalize to a broad selection of circumstances, including the current and future disposition of an aircraft, several prototypical situations were developed in which both behavioral and neurological responses could be monitored simultaneously. Experimental manipulations involved variations in context as well as in the critical stimuli. The introduction of incongruity between context and critical stimuli permitted the behavioral and neurophysiological assessment of the effects of potentially hazardous mental states.

Behavioral and technological advances in cognitive neuroscience have increased the understanding of the relation between mental states and neurological activity in the brain. These advances have been along two fronts: Measures of the short-term (0 - 1000 ms.) responses to discrete events and the long-term (>2.50 s.) correlates to various "states of mind".

In the short term, the occurrence of a discrete environmental stimulus elicits sequences of neural activity in the brain that correspond to well-documented events in information processing. These are "event related potentials" or ERPs. One highly studied ERP component is the "orientation" negative potential at about 100 ms. (N100). This is followed in approximately another 100 ms, by a "labeling" wave (N200) as the subject recognizes the stimulus. The sequences of negative polarization are differentiated by the occurrence of the stimulus in either the auditory or visual modality (Näätänen, 1990). As described by Cacioppo and Tassinary (1990), the amplitude of the N100 (also known as the Processing Negativity) appears to reflect the selection of information from a particular perceptual channel. The amplitude of the N200 component reflects the detection of deviant features. Both the N100 and the N200 measures actually refer to a family of components, one

for each modality, that are similar in function and latency. For example, different N200s can be observed for the visual modality, showing a maximum at the occipital electrodes, and for the auditory modality, showing a maximum at the central or frontal electrode.

Following labeling, stimuli are categorized by the subject. The orienting and naming processes are relatively automatic, whereas categorization can be controlled to some extent (McLeod, 1990; Neely, 1977). The categorization process is indicated by a positive polarization at 300 ms. (P300) and is no longer differentiated by auditory or visual presentation mode. Unexpected events that are relevant to the subject's task elicit large P300s (Cacioppo & Tassinary, 1990). The amplitude of the P300 is sensitive to the subjective probability of task-relevant events, and also varies in amplitude as a function of the task relevance and utility of the eliciting event. Rare events per se do not elicit the P300, as the P300 is related to the processing resources demanded by a particular task.

Of special interest at this point in the ERP sequence is the occasional appearance of a depolarization of neural activity at 400 ms. (N400). This negative potential corresponds to a categorization failure, as may be produced by incongruity of the

stimulus (Kutas & Hillyard, 1980; Van Petten & Kutas, 1990). The N400 ERP component appears to be specifically sensitive to the violation of semantic expectancies. Although not well established, there may then be a positive polarization at approximately 600 ms. (P600) that corresponds to incongruity resolution (Neville, Nicol, Barss, Forster, & Garrett, 1991).

Two caveats are necessary when matching neurophysiology to cognition. First, the neural activity precedes the overt behavior. Behavioral labeling and categorizing are not accomplished until about 500 msec. following stimulus presentation (Posner & Mitchell, 1967; Newell, 1990). Furthermore, the waves of polarization suggests that these activities occur in sequence. The theoretical argument between parallel and serial descriptions of information processing is notoriously complicated (Townsend, 1990). Nevertheless, the most elegant description of the discrimination, naming, and categorization processes must account for various interference phenomena by assuming that the activities are carried out in parallel. Thus, the peaks of the electrical waves in ERPs indicate maximum activity. The processes themselves are all initiated at the occurrence of the stimulus and are continued simultaneously (Posner, 1978).

The merging of the auditory and visual input and the development of controllable input monitoring are indications of attentional mechanisms. These mechanisms imply what used to be described as "early" vs. "late" models of attention, but have more recently and more accurately become known as "data-driven" and "concept-driven" aspects of attention. Our research has replicated these phenomenon and extended the delineation of their occurrence. The incongruity (N400) potential has been demonstrated in verbal decision making without the necessity for specific framing (Derks, Gillikin, Bartolome, & Bogart, 1992). The N400 and a possible incongruity-resolution potential (P600) have been observed in complex verbal material with resolution pivoting on a final phrase (Derks, Gillikin, & Bogart, 1991). These event related potentials in response to incongruity have been found to occur throughout the brain, with consistency within single subjects, and variability between subjects as a function of individual differences.

It is in the function of the brain as a whole that the understanding of long-term electrical activity and its correlation with both trait and state variables has advanced. Through simultaneous measurement from multiple electrodes, the relative activity and wave patterns of the whole brain can be examined. Relations

among particular brain locations and behavior that were previously inferred from lesions can now be measured directly. Although particular brain locations may be primarily responsible for certain tasks (auditory versus visual input; verbal versus spatial/patterned information; speech production versus speech comprehension), it is becoming clear that patterns of excitation and inhibition in the whole brain are implicated in every task. These patterns can be shown to relate to both trait or personality variables (John, et al, 1988) and state or information-processing variables (Posner, et al, 1988).

To some degree our results have confirmed both the importance of idiosyncratic characteristics of individual subjects, as well as defining some general similarities in response among subjects. In the recognition and resolution of ambiguity, all participants show heightened activity in both the left (verbal) and the right (whole-pattern) cerebral hemispheres. The degree to which these functions overlap may indicate different degrees of lateralization and, perhaps, more ready access to possible resolutions.

Delta rhythms (slow waves that possibly correspond to hazardous mental states) also appear in the occipital region during incongruity recognition and

resolution. The amount of delta varies among subjects. Attempts to manipulate these affective mental states within subjects have met with varying success. Attempts to experimentally induce feelings of "invulnerability" (elation) and "resignation" (depression), using the Velten (1968) mood induction procedure have not significantly affected long-term brain activity, although some consistencies are observed. The manipulation has, however, influenced overt responses to incongruity. Other investigators have reported that a more trait oriented, between-subjects approach may produce an effect in evoked visual potentials (Joost, Bach, & Schulte-Mönting, 1992).

In order to study incongruity, incongruity resolution, mood state and the corresponding neurological markers, a prototypical situation was developed which could be generalized to a broad selection of circumstances, including the current and future disposition of aircraft. This experimental situation is composed of a target and a background of distracting stimuli. Target and background are manipulated to simulate the circumstances of various pattern recognition tasks and their corresponding states of situational awareness.

The target may vary over two dimensions: (1) pattern and (2) complexity. The pattern of the target determines its predictability. Thus repetitive targets (recursive processes) are predictable because their occurrence depends on some regular pattern in time and/or space. At the other extreme are random, unpredictable occurrences of the target. Along the entire dimension, however, there are different degrees of restriction (stochastic processes). In other words, within a general pattern, probabilistic disruptions reduce, but do not eliminate, the opportunity for prediction accuracy.

The predictability of a target depends on the extent of the restrictions, either recursive or stochastic, and the number of elements in the pattern, including the target (complexity). The occurrence of one continuous target represents the most simple case. Multiple elements extended over a long pattern would be an example of increased complexity. Stochastic patterns and complex stimuli can be used to test the limits of situational awareness.

Background stimuli are defined in terms of their relation to the target and to themselves. Thus distracting background stimuli may be relatively similar to target stimuli in their physical construction. Furthermore, background stimuli may also

vary in complexity. Their complexity is a function of the number of different elements, e.g., different stimuli that are presented with the targets themselves. These dimensions are typical of the stimulus conditions usually studied by cognitive psychologists (Anderson, 1990; Martindale, 1990). The information content of a situation can be clearly and accurately specified. The mismatch between situation and cognizance (awareness and control) can be operationally defined and measured.

To illustrate the use of these target-background manipulations in the study of pattern recognition and situational awareness, six specific paradigms are offered. These paradigms have been proposed as relevant to the six mental states that have been found to be critical in situational cognizance (Pope, 1990). The quotations below are taken from pilots involved in air traffic incidents (Pantine and Mellone, 1989). They are chosen to be illustrative of the six mental states described in previous research (Pope, 1990) as attentive, focused, complacent, absorbed, preoccupied, and vigilant. A possible experimental analogue is given to illustrate how each mental state could be replicated in the laboratory, as well as the description of the corresponding cognitive process in pattern-recognition terminology. The six mental states are as follows:

1. Attentive - A vigilant pilot monitors changes in the instruments available for observation, anticipating their future states: "Pay close attention to clearances, question unusual clearances...pilots and controllers can make mistakes, and last and certainly the main concern is be alert." (#89626).

   Experimental Analogue: Subject monitors a game of chance with an investment in the outcome.

   Pattern Recognition: Target has intermediate complexity and is stochastic. Prediction accuracy is potentially above chance.

2. Focused - A pilot monitors a single important aspect of the situation with less awareness of other aspects: "I was concentrating on the captain's use of new equipment...new electronic gadgetry." (#68957). "I was flying with a new F/O and I was paying more attention to the pre-takeoff checklist and briefing him, than I normally would have, rather than thinking about where I was taxiing." (#49738)

   Experimental Analogue: A light appears regularly and requires the subject to make a simple response.

Pattern Recognition: Target has intermediate complexity and is recursive. Prediction accuracy is potentially perfect.

3. Complacent - A pilot is not challenged and does not attend an automatic system, leading to errors when something goes wrong: "I still do not know what caused the map display to be off course. The entire system usually performs so magnificently that I may be becoming complacent and totally relying on its accuracy." (#39567) "In flying for a commuter airline, we fly to many airports many times a day, as many as 10 in one day. We seem to be complacent about these airports. As is said, flying is hours and hours of pure boredom, but with a few moments of pure excitement." (#44065)

Experimental Analogue: Subject is given experience with operating automated system at a perfect level of predictability, then is required to operate the system at a decreased level of predictability.

Pattern Recognition: A relatively simple, recursive target is shifted to a similar, but stochastic pattern.

4. Absorbed - A pilot monitors one simple task to the exclusion of other equally or perhaps more important tasks: "The F/O mentioned at least twice that 'we're approaching 30 mi.', but I was so preoccupied [absorbed] with reprogramming the FMC that his warnings didn't register with me." (#95531) "When you fly a noisy turboprop for days, you just get very tired. Sometimes I think the noise and motion actually hypnotizes you."(#49738)

   Experimental Analogue: Subject is instructed to develop and maintain a very narrow focus of attention on a single feature of the environment.

   Pattern Recognition: Simple recursive target in a complex, dissimilar background.

5. Preoccupied - A pilot becomes involved in thinking about events outside the immediate situation, without attending to the task at hand: "I feel a major cause of this incident was a preoccupation by the captain caused by the crisis situation of our airline, leaving all our futures in serious doubt. The previous two-three hours of conversation were totally devoted to what was happening and conjecture on what might happen... He was worrying about

his career and the fate of our airline."(#49963)

Experimental Analogue: Subject is given a primary task (engaging, investing) that is interrupted by a secondary task (i.e. thinking about a problem) with the understanding that the primary task will soon reappear to be completed.

Pattern Recognition: A complex recursive target is learned, then shifted to a simpler, different target. The original target is reintroduced.

6. Vigilant - (auditory-verbal) - A pilot responds to verbal information and instructions: "'Clearance on request' was heard by us as 'cleared on course'. Say it quickly over a radio and the similarity becomes clear. However, it's just incredible to me that we accepted what we heard as being reasonable and appropriate...not only did we not hear the words cleared for takeoff' but we accepted a supposed cleared on course' clearance from a ground controller." (#66783).

Experimental Analogue: Words are presented sequentially and the subject makes semantic categorizations.

Pattern Recognition: Complex verbal targets are categorized according to some general rule.

The investigation of the behavioral effects of such manipulations is the essential goal of cognitive psychology. In this context "hazardous mental states" are those states of mind that interfere with the accurate processing of the environment and the placement of specific events in it. Along similar lines, hazardous thought processes or mental states have been described by Lawton (1984) as follows:

1. Anti-Authority ("Don't tell me!") - This thought pattern is demonstrated by people who do not like anyone telling them what to do. They have a tendency to disregard rules, regulations and procedures.

2. Impulsivity ("Do something quickly!") - These people frequently feel the need to do something, anything, immediately, even if it is wrong. They do not stop to think about the consequences and select the best alternative. Instead, they do the first thing that comes to mind.

3. Invulnerability ("It can't happen to

me.") - Accidents happen to others, not me, is the result of this thought pattern. These individuals know accidents can and do happen, but they believe that they personally will never be involved.

4. Macho ("I can do it.") - These people are always trying to prove that they are better than anyone else. They "prove" themselves by taking risks and by trying to impress others.

5. Resignation ("What's the use?") - Individuals with this thought pattern do not believe that their actions can make a great deal of difference in what happens to them. They do not believe that they can influence the outcome of a situation. For better or worse, they leave action to others.

Lawton's concepts of hazardous thoughts may provide a linkage between mental states and personality trait factors, if traits are considered as a predominating pattern of use of particular mental approaches. For example, the complacent mental state may lead to impulsive, invulnerable or macho thought processes. The focused state could lead to anti-authority thoughts. Most specifically, the preoccupied individual may have thoughts of resignation as described above.

Another analogy can be drawn from clinical psychology, specifically from the Diagnostic and Statistical Manual of Mental Disorders known as DSM-III-R (APA, 1987). This text represents the descriptive handbook for mental illness. Based on DSM III-R diagnostic categories, Oldham & Morris (1990) proposed parallel personality types that, although not clinically debilitative, can lead to behavior similar to that found in various hazardous mental states under study in the laboratory. In our current research paradigm, the attentive state may be likened to Oldham and Morris's conscientious personality. In balance, this would be a desirable trait and an effective state in which to attend to flight responsibilities. Taken to a clinical extreme, however, the behavior could become symptomatic of obsessive-compulsive personality disorder. This state of mind would not lead to the effective problem solving necessary for appropriate situational awareness and control.

Similarly, the absorbed mental state corresponds to the Oldham and Morris's vigilant personality type, but, in the extreme, falls in the paranoid clinical diagnosis. A focused mental state corresponds to their aggressive personality type. Properly channeled aggression can be an effective mental state. At the clinical extreme, however, it becomes sadism. Less

sinister, but also hazardous, are the preoccupied and complacent mental states. Oldham and Morris describe these two patterns, respectively, as the leisurely personality and self-confident personalities. These are not effective cognitive styles when faced with an emergency situation. Furthermore, at the clinical extreme they become passive-aggressive and narcissistic personality disorders. No clinical definition is necessary to indicate the potential complications of such hazardous thought patterns in an emergency. The implication of these descriptions are twofold. First, there is a balance, an optimum level, of such mental states. Second, there is potential danger in an over commitment to any one of them. Research combining the state and trait factors, as exemplified by both Lawton (1984) and Oldham and Morris (1990) remains in the preliminary stages. Although it is not a focus of the current research, our findings of replicable patterns of individual neurological differences would add confirmation to the potential for integration of state and trait literature in this area.

Broadly conceived, the research reported here describes the process of induction of various mental states. Our goals were to measure and to manipulate both the behavioral and the neurological correlates of particular mental states that have previously been

demonstrated to be either beneficial or deleterious to in-flight performance situations. The experimental paradigm involved developing a context of which the participants were aware, followed by the introduction of an incongruity into that context. The empirical questions involved how the incongruity was resolved and the consequent effects on mental state. The dependent variables were measures of both the short-term ERP changes and the longer-term brain mapping indications of predominant mental states. A summary outline of the experimental design is presented in Appendix 1.

The mission of NASA Flight Management Division and Human/Automation Integration Branch centers on the understanding and improvement of interaction between a complex system and a human operator. Specifically, the goal is improved efficiency through better operative procedures and control strategies. More efficient performance in demanding flight environments depends on improved situational awareness and replanning for fault management.

Although the ultimate test of this human-system integration occurs in genuine flight environments, prior examination in piloted simulations and laboratory tests are necessary to develop and verify psychological and physiological correlates of "situational awareness", fault management", and "improved

efficiency". These laboratory tasks, then, must simulate the complexity and change that require conscious monitoring, involvement, and control. Situational awareness is the measure of monitoring and involvement while fault management is evaluated by success of controlling behavior.

To maintain control, a mental model of the environment must be constructed and departures, i.e. mismatches, between that model and the environment must be noted and corrected. Failures to recognize departures from the norm may be attributed to absorption (failure to monitor multiple inputs) or preoccupation (monitoring irrelevant inputs). Continued congruity in the environment can lead to hazardous states that are indicated by certain behavioral and neurophysiological markers. When an incongruity occurs it must be recognized to be resolved. Event related potentials (ERPs) in brain activity show different patterns if the event is normal or incongruous. Incongruity resolution depends on these differences, their production, and their measurement.

The mental models of the environment that are constructed by humans are heavily dependent on language, although imagery also plays an important role. Language, while it defines and stabilizes these models, is a source of ambiguity and potential

incongruity. Consequently, language processing is a powerful tool for the study of factors associated with situational awareness and fault detection. Much of the ERP research is based on semantic processing tasks. In the current research, the experimental tasks were verbal in nature, through both the visual and auditory channels. In this respect, the tasks are analogous to many cockpit tasks requiring visual and auditory information processing, at times simultaneously. The verbal problems of ambiguity and incongruity thus are clearly relevant to the ways in which flight information is patterned and in-flight problems are solved.

Under appropriate circumstances, the behavioral responses that accompany incongruity resolution can include smiling and laughter. Clearly, the experience of humor is the prototype of complex information processing, incongruity recognition and resolution. A direct and elegant model of situational awareness and fault detection is the information processing inherent in the evocation of humor.

Furthermore, the study of humor yields additional benefits relevant to the mission of flight management and human/automation integration. The individual health and group-integration benefits of certain humor messages is receiving support from careful research and

application (Lefcourt & Martin, 1986). Increased understanding of these phenomena will lead to applications for improved performance of crew-machine systems and better, more congenial, management of crew workload and the alleviation of stress. Humor is no panacea. Therefore, it must be better understood to be properly used. Properly used it is a powerful human mechanism for coping with complexity, incongruity, and hazardous mental states.

Method

Subjects. The participants in this research were recruited from a college population. They were paid minimum wage for their travel time, preparation time, and the time of actual experimentation. Each session took four hours or a total of eight hours for both required sessions. The payment per hour ranged from $3.85 to $4.15 per hour as minimum wage increased during the two years of research. All participants were treated according to the ethical principles of the American Psychological Association. The senior investigators participated as subjects in the research before any volunteers were tested. The research was approved by the NASA Human Research Board and the Research Ethics Committee of the College of William and Mary.

Eighteen participants were tested, nine males and nine females. Without facilities for pre-testing, and with modifications in the procedure over the course of the research, not all of the data supplied by the participants could be used in all of the various studies reported here. Furthermore, without facilities for pre-testing off-site before sessions scheduled at the NASA-Langley facility, some unusable data was collected, resulting in lost time and effort. For example, some subjects brain maps were found to be overlaid with superficial artifacts of measurement which reduced the usefulness of their results. Consequently no experiment actually had a population equal to all eighteen subjects tested. Further research should utilize off-site pre-testing to reduce these loses of data.

Equipment. Brain activity was recorded with a Cadwell Spectrum-32 Topographical Brain Mapper with twenty-one electrodes arranged in the international 10-20 system. (Jasper, 1958). Reference electrodes were connected to the right and left earlobes. Electrode installation was facilitated by the use of an electrode cap manufactured by ElectroCap Incorporated. A Grass silver-silver chloride EOG electrode was installed on the outer canthus of the right eye. The two EMG electrodes were secured over the right zygomaticus

muscles to detect smiling. All electrode impedances were verified to be less than five thousand Ohms using the Spectrum-32 impedance checking routines.

The subject was seated in an environmentally controlled test chamber. Auditory stimuli were presented through a PSI model HSI-S5 Piezo dynamic stereo headset with attached boom microphone. Visual stimuli were presented on a CRT screen and could be controlled by the participant.

During a fifteen minute pre-test period, the subject listened to a pre-recorded relaxation protocol. The directions were intended to produce an eyes-open mental state of alert, responsive relaxation. All EEG, EOG, EMG and auditory stimuli were digitized at 250 samples per second and were recorded on optical disk by Spectrum-32. The recording setting were low cut 0.5 Hz, high 70Hz, 60 Hz notch filter on, sensitivity 7.5 mV per mm.

Each of two recording sessions consisted of an eyes open baseline, an eyes closed baseline, and a word counting session. The word counting task required the counting of the number of nouns in a list of mixed parts of speech. The data recording time for each of these sessions was adjusted so that at least two minutes of artifact-free EEG could be selected from each one. Baseline sessions were followed by 60 to 90

minutes of data recording while the subject listened to or read experimental material.

Analysis: Topographical Brain Maps

Topographical brain maps were constructed from the stored data using Spectrum-32 Q-EEG analysis software. For the Various mental states, forty-eight epochs (2.5 s each) of artifact-free EEG were manually selected with automatic artifact detection activated. An additional level of analysis was conducted using the Spectrum-23 uncorrelated test analysis to isolate the differences in activity between states.

Analysis: Event-related Potential

The digitized data for previously selected epochs were exported to an IBM AT computer running Brain Stat (Version 2.0 from Tauagagreining h.f.). Epochs were examined individually for artifacts. The remaining epochs were averaged to form an ERP file, filtered with a digital high-cut filter set at 35 Hz and smoothed with an eight point window average. A series of topographical brain maps was generated from the filtered and smoothed data that showed cortical voltage every 20 ms up to 600 ms. Each ERP map averaged activity over the previous five ms.

Procedure

The eighteen subjects participated in four consecutive experimental procedures. The four

procedures will be described together as the participants experienced them chronologically. The results of each experiment will then be presented and discussed separately. A general discussion will conclude this report.

In the first experimental procedure, each participant was presented with the mental state induction techniques described elsewhere by Pope and Bogart (1992). Briefly, EEG activity was monitored first with eyes open and then with eyes closed. Next, the following mental states were induced for about five minutes each: "attentive" (monitor events on CRT screen); "focused" (monitor specific event); "absorbed" (monitor event off screen); and "preoccupied" (think of a problem you are having). These manipulations have shown consistent effects in past research and were to be compared to the EEG mapping in the subsequent experimental conditions.

In the second experimental phase, a list of 105 words, nouns and verbs, was presented. Presentation modality was varied, with certain subjects receiving auditory presentation, others visual, and some subjects undergoing both sets of presentation. The words chosen had been judged as either obviously a noun, obviously a verb, or ambiguous by college students in a class on cognition and thinking during the section on

psycholinguistics. The list and the ratings of each word are presented in Appendix 2. The subjects task was to count the number of either nouns or verbs. The target designation was counterbalanced over sessions. This experiment was intended to examine event related potentials to stimuli of varying ambiguity when a decision was required. Thus an incongruity might or might not need to be resolved while a decision had to be made.

In the third experimental procedure, an attempt was made to induce a positive or negative affective state (Velten, 1968). A series of statements were either heard or actively read by the participant, with the intent of inducing the appropriate mental state. These statements are given in Appendix 3. Extensive research using this Velten technique has demonstrated its effectiveness (Larsen & Sinnett, 1991). This manipulation presented an opportunity to validate the individual brain mapping corresponding to hazardous mental states as collected in the first experiment. In addition, the induced states, even if they did not correspond to the hazardous states of phase one, were predicted to influence the incongruity resolution tested in the fourth and final phase.

In the fourth experiment, verbal passages were presented that raised a potential incongruity to be

resolved in the final word or phrase. Again the presentations were both auditory and visual. In the auditory condition, the prerecorded passages were read with a pause preceding the incongruity resolution. In the visual condition, the participant controlled the appearance of the passage and its resolution. A press of the space bar presented the verbal material on the computer screen. When the passage was read up to the resolution point, another press of the space bar revealed the potential resolution. Two sets of material were selected for presentation, one on each of the two experimental sessions. The materials for Experiment 4 are included as Appendix 4. In this condition, the subject did not need to make a decision, as in Experiment 2 with ambiguous words. However, the presence of incongruity and its resolution, whether active or passive, was extant in both experimental situations.

The entire experimental procedure lasted for about two hours. When time is added for the EEG electrode placement and removal, as well as travel between Williamsburg and NASA-Langley, each session required about four hours. The four-part experimental sequence was repeated in the same order for the second session which was conducted about one week later, although with counterbalancing of materials as indicated above. All

subjects were debriefed and given feedback about their performance in the tasks. Participants were shown representative brain mappings and ERP data, as well as being familiarized with the purpose and goals of the studies. Subjects were followed up for minor discomforts, with no continuing problems observed.

Experiment 1 - Induction of mental states:

Results - Baseline data was recorded for all eighteen subjects during this phase of the experiment which replicated earlier findings in this laboratory (Pope & Bogart, 1992). The mental states induced were those defined as attentive, focused, absorbed, and preoccupied.

Experiment 2- Sequentially presented unrelated words:

Results- Eight subjects (five males and three females) received auditory presentation of the word lists. Eight others (three males and five females) received the word lists visually. Although visual presentation permitted more precise assessment of ERP activity, the results were essentially equivalent for both conditions.

As expected, there are early differences in the physiological response to auditory and visual stimuli. The auditory cortex is most active for auditory stimuli and the visual cortex is most responsive to visual stimuli. After about 250-300 msec., however, the

neurophysiological activity becomes quite similar regardless of the presentation modality. The transition from sensory specific to more general response may be related to the increased importance of concept- driven versus data-driven information processing. For example, the differences between memory for auditory and visual input are more pronounced in short-term, working memory than in long-term memory (Penny, 1989, Small, 1992).

Figure 1 shows a typical ERP activity tracking of the potential related to an event. In this case the event is the presentation of a word to be classified and counted as a noun or verb. The ERP pattern changes from baseline through positive and negative activity as a function of processes performed with maxima and minima at different latencies. This pattern corresponds to the many reports in the literature on event-related potentials. A negative component at 100 msec. corresponds to orientation or attention and is modality specific. A positive wave occurs at about 200-300 msec. (P300) and corresponds to recognition. Of greatest interest here, however, is the negative component at about 400 msec. (N400). This occurs when there is a mismatch between the stimulus and what was expected for recognition. Previous research has reported this N400 as part of an ongoing sentence

interpretation. Here is occurs as a response to a single word presented without context. The context is supplied by the decision-making task concerning part of speech, noun or verb. The N400 component has also been recorded in a sentence verification paradigm where participants decide whether sentences are positive or negative ("is," or "is not") and whether the sentences are true or false (Fischler, Bloom, Childers, Roucos & Perry, 1983). This paradigm approximates the noun-verb decision making task. In general, research suggests that the N400 is "specifically sensitive to the violation of semantic expectancies" (Cacioppo & Tassinary, 1990).

Insert Figure 1 about here

Of future interest, then, is the effect of words themselves in this context. An examination of the brain maps collected by summing over subjects shows similar ERP patterns for nouns (Figure 2) verbs (Figure 3) and ambiguous words (Figure 4). The "P300" begins to appear in all three instances at 150 msec. in the central region. Activation spreads through the whole brain, reaching a generalized peak in the right frontal cortex at about 225 msec. The positive activation then moves posteriorly and dissipates at about 325 msec.

FIG 1

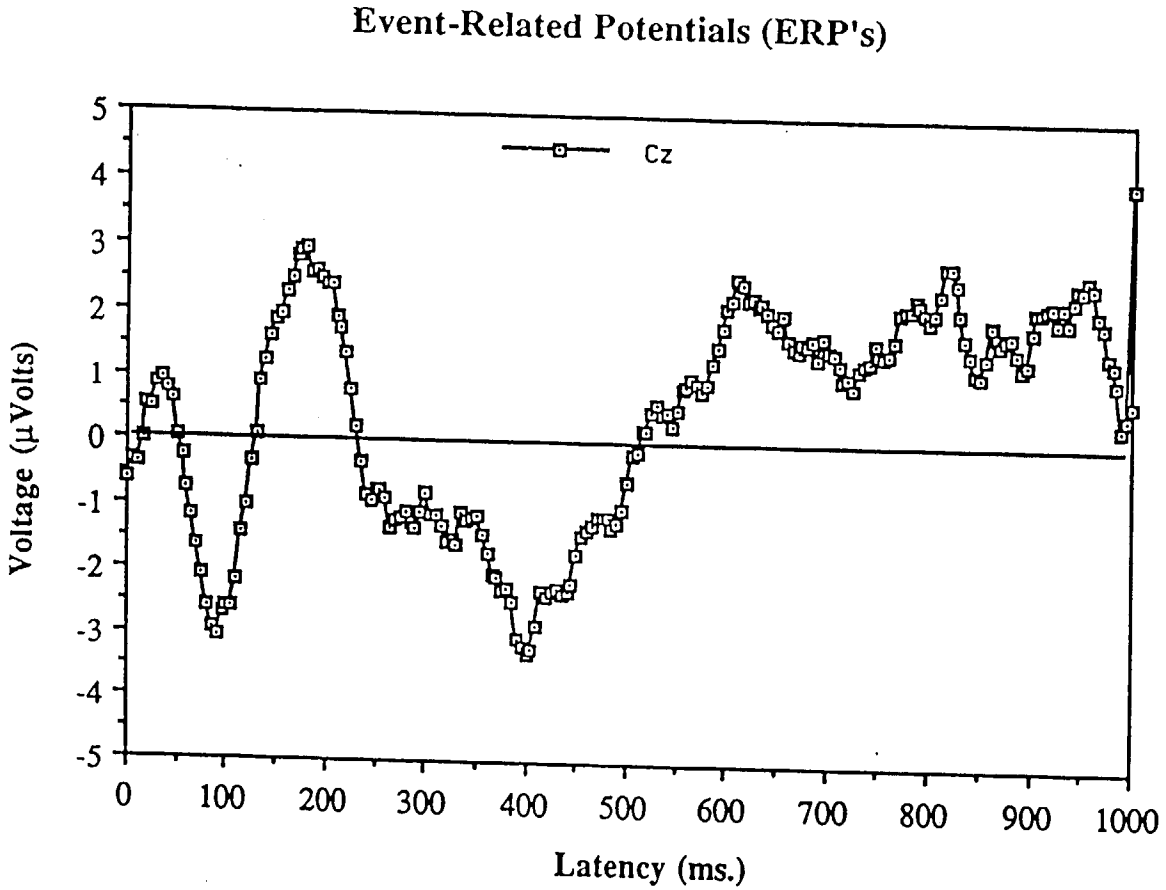


Fig 1. Average Event-Related Potentials (ERP's) Showing Late Negativity. (N = 15)

For all words types, a subsequent negative polarization is evident and widespread from 375 to 475 msec. One possible interpretation of this finding is that although a decision can be made unambiguously, the system goes through a "double-check."

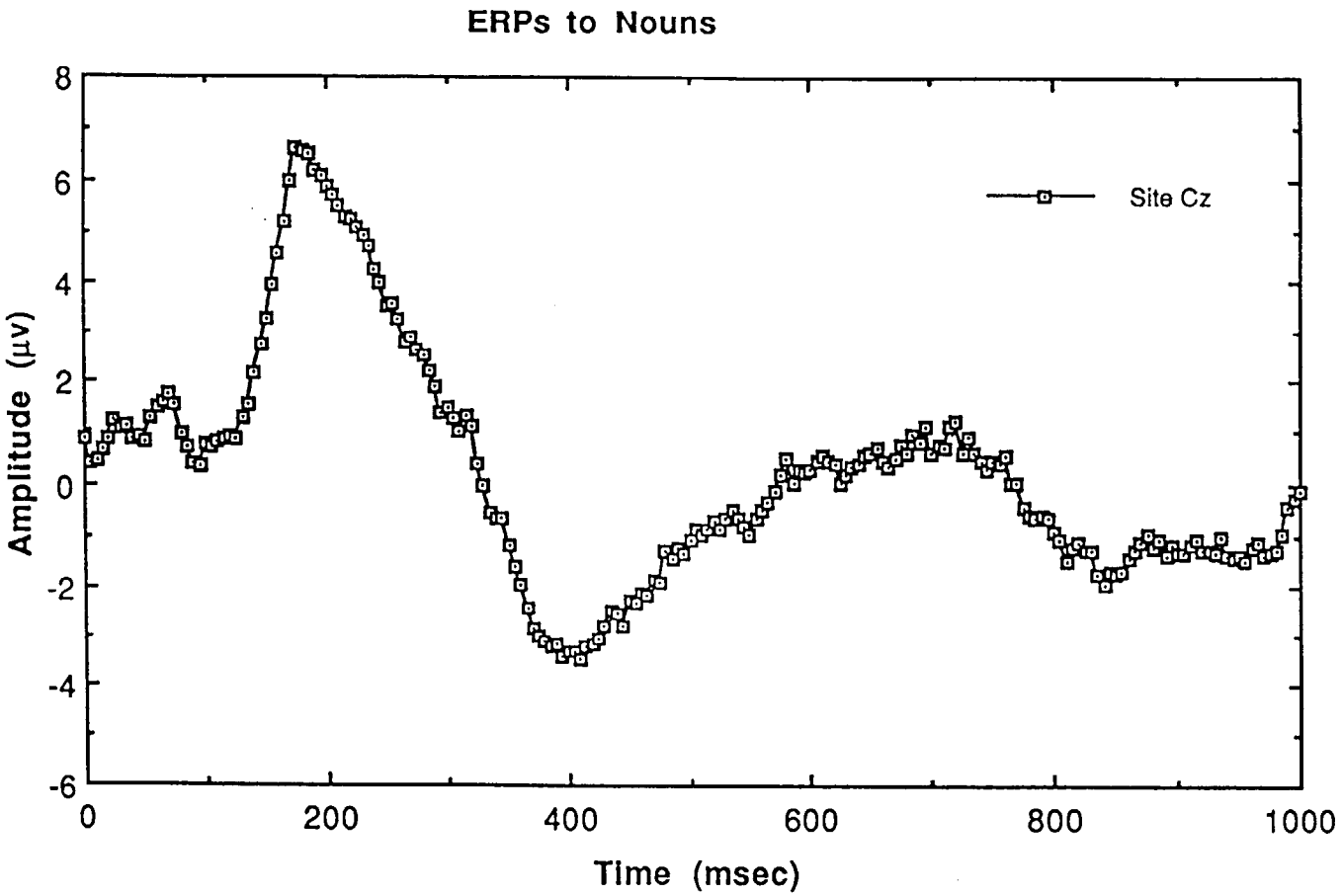
Insert Figures 2, 3, & 4 about here

Experiment 3 - Neurological correlates of positive and negative affective states:

Results - When the research was initiated it was evident that long-term mental states could be measured neurometrically (John, Pricher, Fridman & Easton, 1988; Robinson & Szetela, 1981;, Pricher, John, Essie-Peppard, & Alper, 1990). Acute affective changes, however, had not been examined. Very recently, specific changes in electrical activity in the brain have been correlated with temporary emotional modification (Hinrics & Machleidt, 1992; Stenberg, 1992). These investigators employed an "imagery" procedure in which the subjects used their own past experience to reinstate a particular emotional state.

The Velten technique employed in the present research has been effective in producing changes in

FIG 2


ERPs to Nouns
Site Cz
Amplitude (μv)
8
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000
Time (msec)

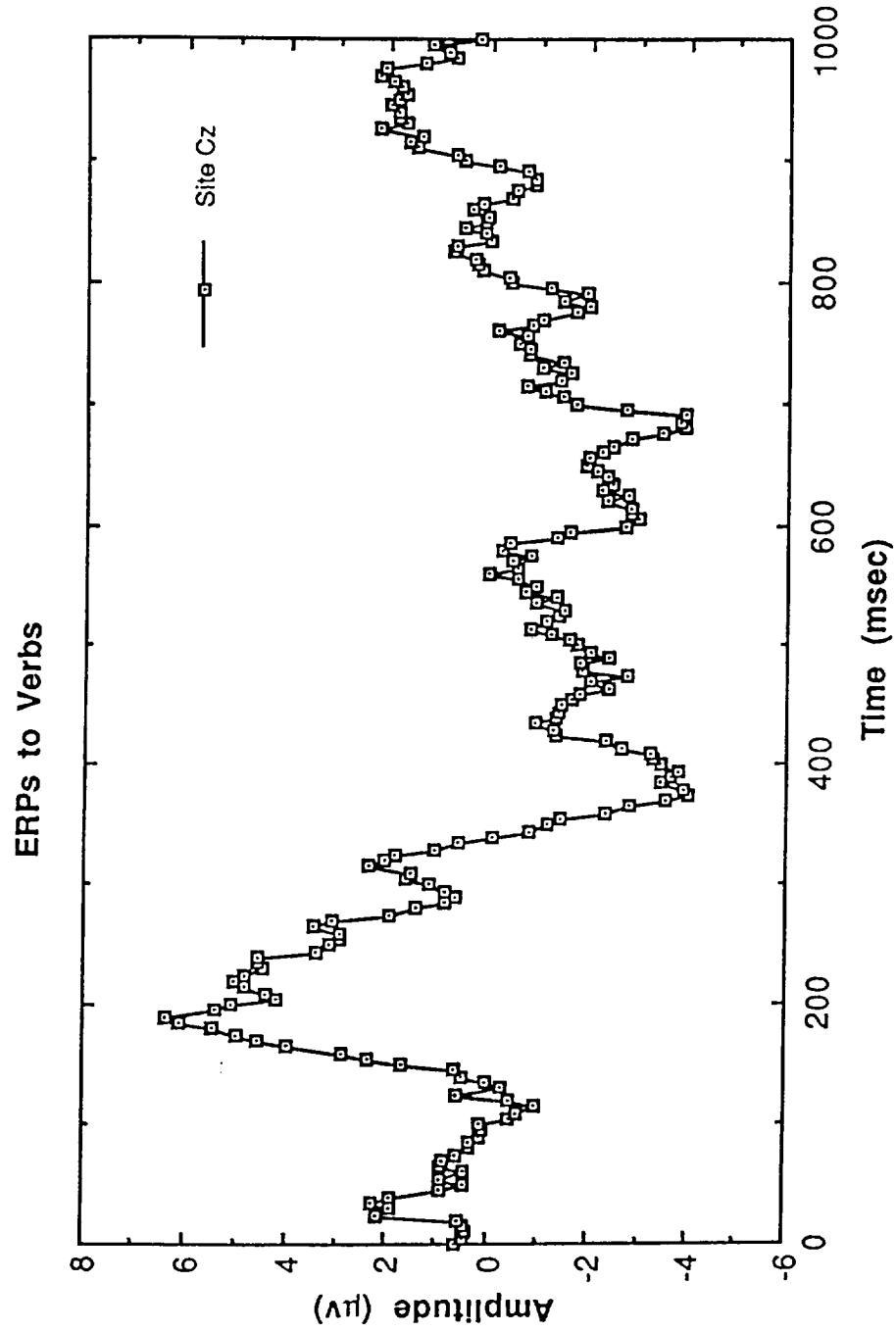
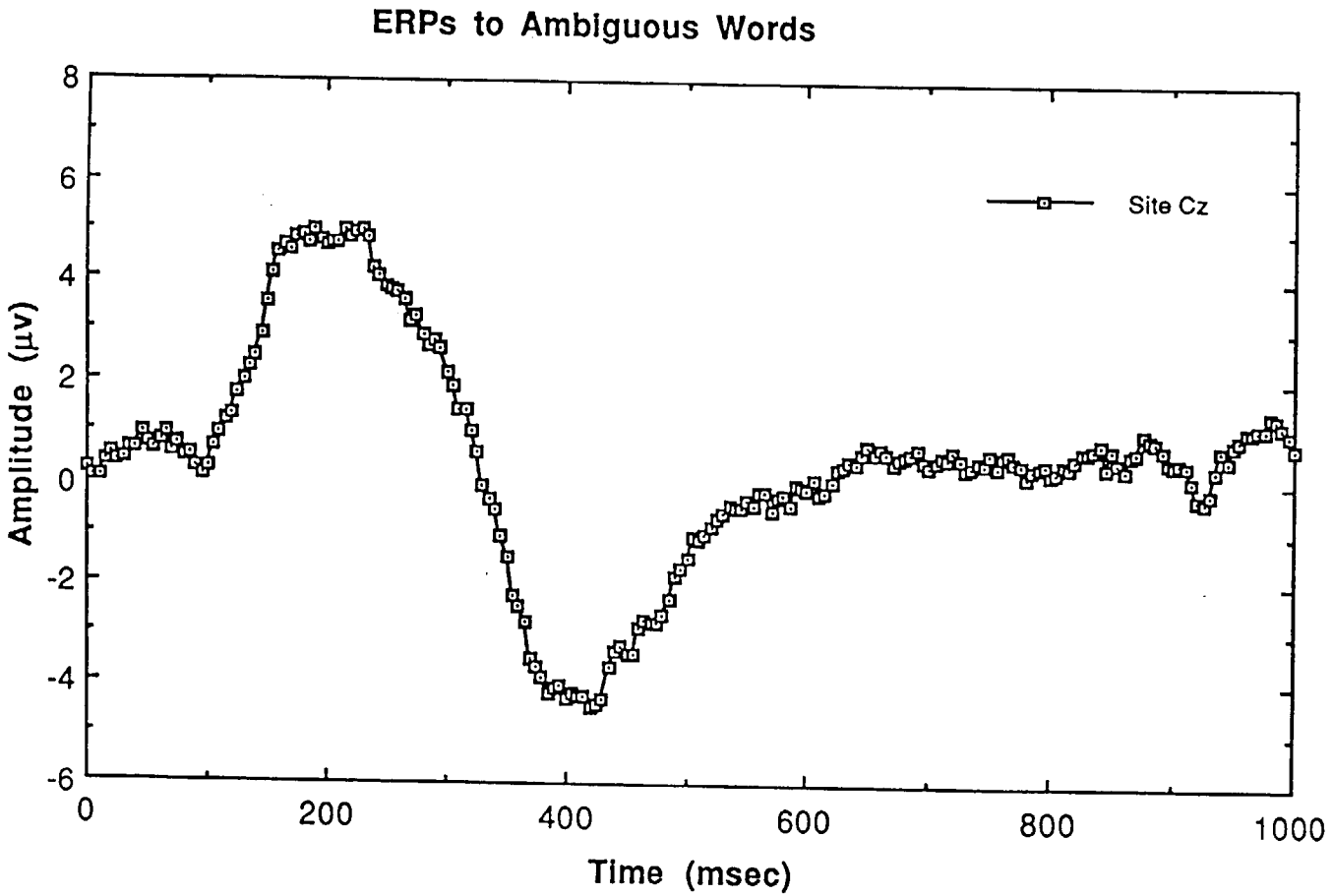

ERPs to Verbs
Site Cz
Amplitude (μv)
Time (msec)
8
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000

FIG 3

FIG 4


ERPs to Ambiguous Words
Site Cz
Amplitude (μv)
8
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000
Time (msec)

behavior associated with affective states as demonstrated in a meta-analysis of 341 studies reporting 841 manipulations (Larsen & Sinnett, 1991). In this study, the participants informally reported an appropriate, if temporary, change in affective state. In the subsequent manipulations of this study (incongruous material), there was also an insignificant, but appropriate, difference in responsiveness depending on the prior affective state.

The neurophysiological changes, however, were weak and inconsistent when examined in the brain maps. The changes from pre- to post-affective manipulation are less than a standard deviation and are not reliably consistent with the original productions, or those described in other, more successful studies.

The changes in directionality of neurological activity do, however, show consistencies when analyzed by individual electrodes. A preliminary discriminant analysis has revealed consistent effects from positive and negative manipulations that are not visible to the naked eye. The discriminant matrices for positive and negative affective states are shown in Table 1. This analysis requires very large amounts of computation space and time. Consequently, the comparison of additional participant data sets as well as their comparison with the individual states of attentive,

focused, absorbed, and pre-occupied must await access to NASA's super computer.

Insert Table 1 about here

Experiment 4 - Neurometric and behavioral responses to discovered incongruity;

Results - In a preliminary work, it was observed that the occurrence of an incongruity and subsequent resolution in verbal material elicited the sequence of ERP polarity changes associated with the presentation of incongruous words in sentences (Derks, Gillikin, & Bogart, 1991). In Experiment 4, the behavioral response to incongruity was measured simultaneously, and was compared to the corresponding ERPs. The behavioral facial response to incongruity resolution can be a tightening of the zygomatic and orbicular muscles (Duschene, 1862/1990; Ekman, 1992). Although both were monitored in this study, the flexion of the zygomatic was taken as the primary indicator. The response is a simple one and in the context of listening to or reading a story, it is probably an unconditioned reflex to the stimulus of incongruity or surprise. It was hypothesized that a negative affective state would decrease sensitivity to the incongruities in the stories. Table 2 shows frequency

of response, level and ratio of change in the average tension of those responses following the induction of positive or negative states with the Velten procedure.

Insert Table 2 about here

As with the measures of neuroelectrical activity, the effect of affective manipulation is not statistically significant. Frequency of zygomatic response ($t_{(10)}$ = 0.94, p >.20), ratio of change from pre- to post-incongruity ($F_{(1,9)}$ = 2.20, p = .17), and the difference between overall intensity in the zygomatic ($F_{(1,9)}$ = 2.00, p = .19) all fall short of significance. The change from pre- to post- is, of course, significant because the selection of responses was based on this change ($F_{(1,9)}$ = 13.40, p = .005). These results are suggestive, as were the neuroelectric effects, but eleven usable subjects were about half what was needed to demonstrate an effect that is slight and beset with individual differences in response.

The event-related potentials, however, show a clear replication of the original preliminary data. Brain maps of the ERP's show the same progressive change through positive polarization at about 200 to 300 msec (P300), followed by a negative polarization (N400). Furthermore, the activity is evident in both

the left and right hemispheres of the cortex, indicating involvement of both sequential, verbal systems and holistic pattern recognition systems.

Of particular interest is the difference between trials (different verbal segments) which elicit the zygomatic reflex and those that do not. Figures 5, 6, 7, and 8 show the activity from electrodes 11, 12, and 13 summed over nine subjects to indicate more clearly the pattern of activation with time. When the zygomatic reflex occurs, the polarization of the areas measured by these electrodes drops to or below baseline following the peak of positive activity. When there is no zygomatic activity, and presumably an inadequate stimulus for incongruity, the positive wave is less positive and the decrease in polarity does not reach base line. Probably insignificant, but of additional interest, is the fact that following the negative affective manipulation, the appearance of the N400 wave is about 50 msec. quicker than following positive affect.

Insert Figures 5, 6, 7, & 8 about here

General Discussion

From a neurometic mapping perspective, this research has had two general goals. The first was an

FIG 5

Elated Laugh (n=93)

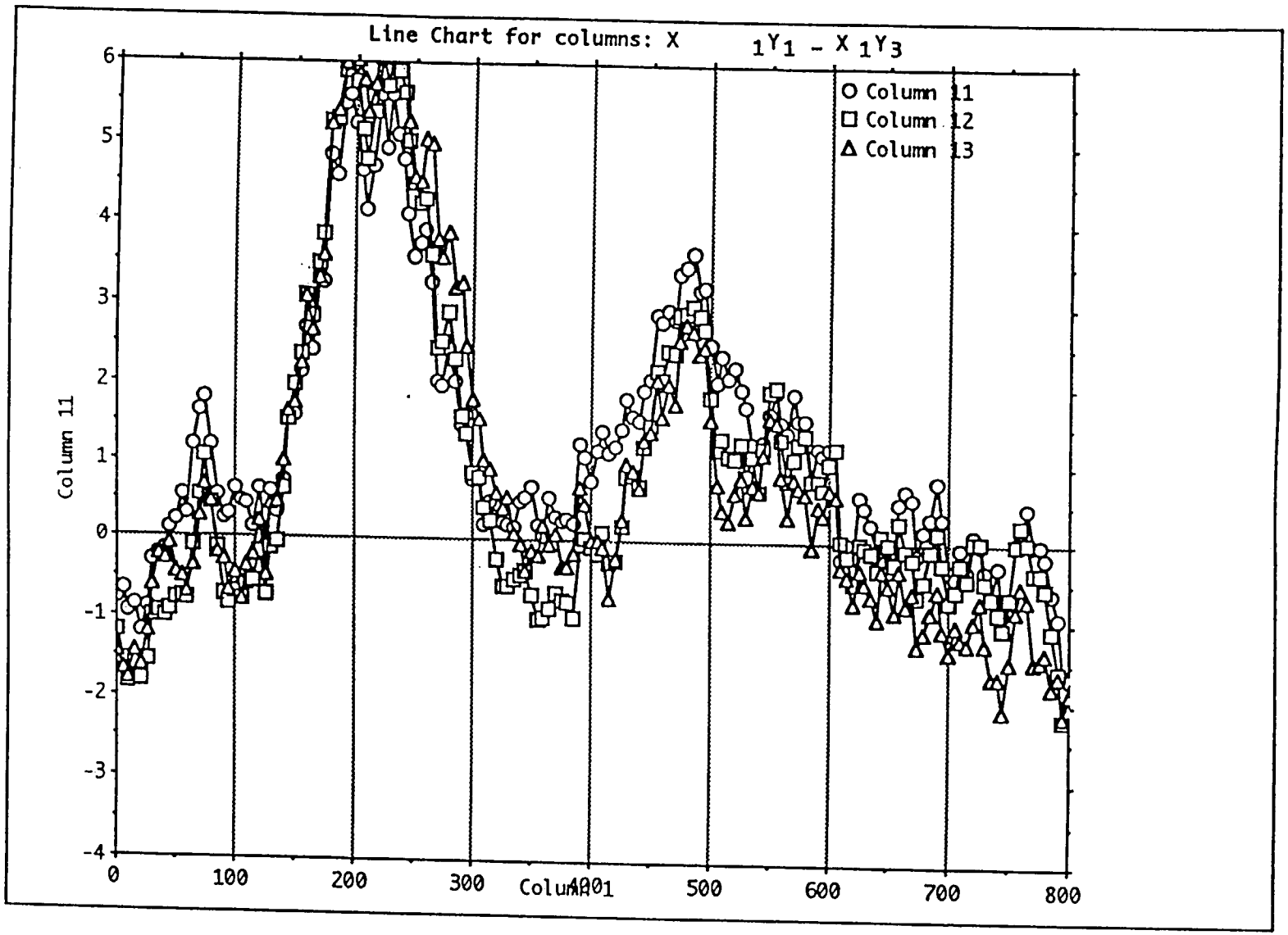


FIG 6

Depressed Laugh (n=79)

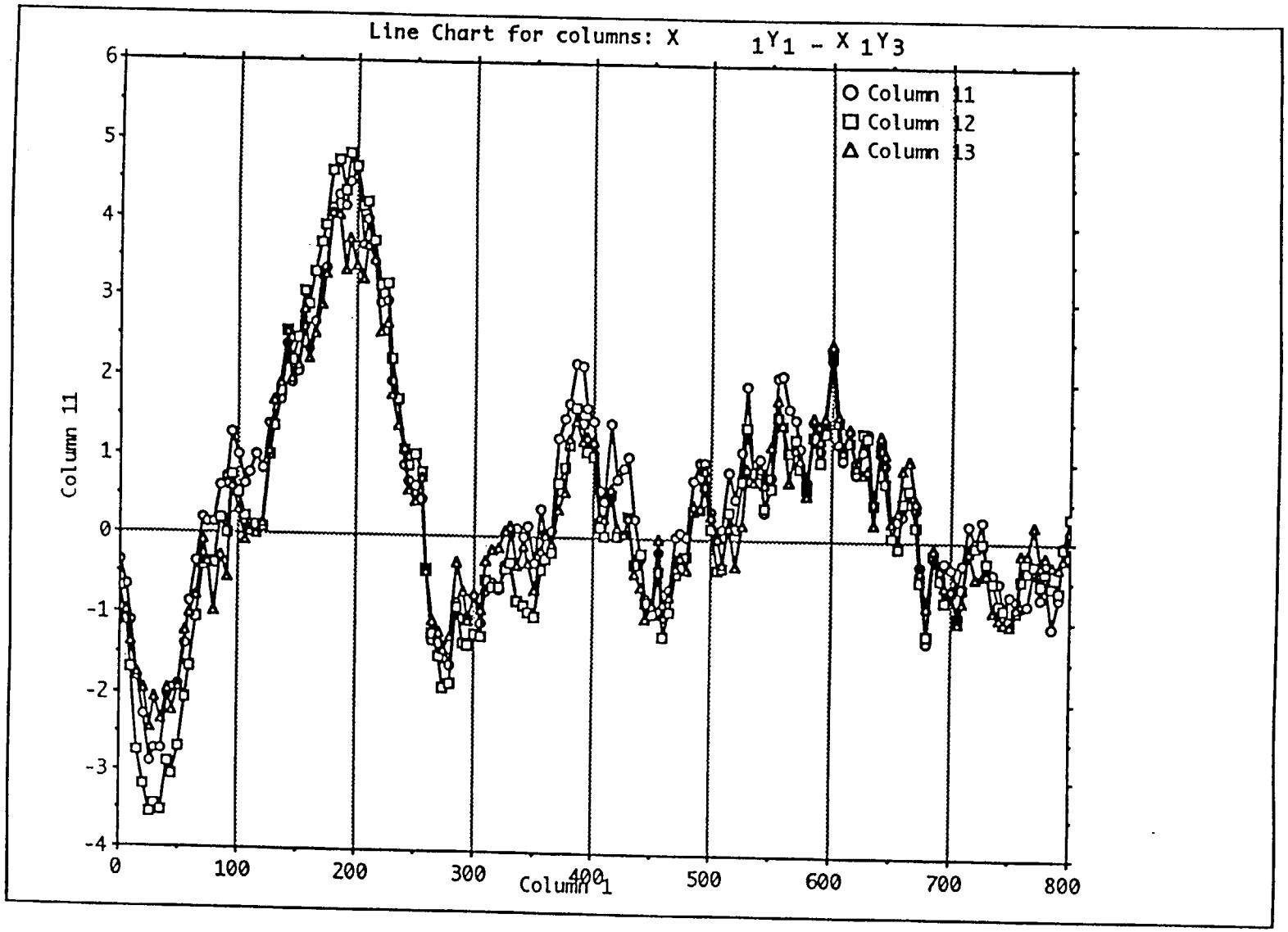


FIG 7

Elated No Laugh (n=138)

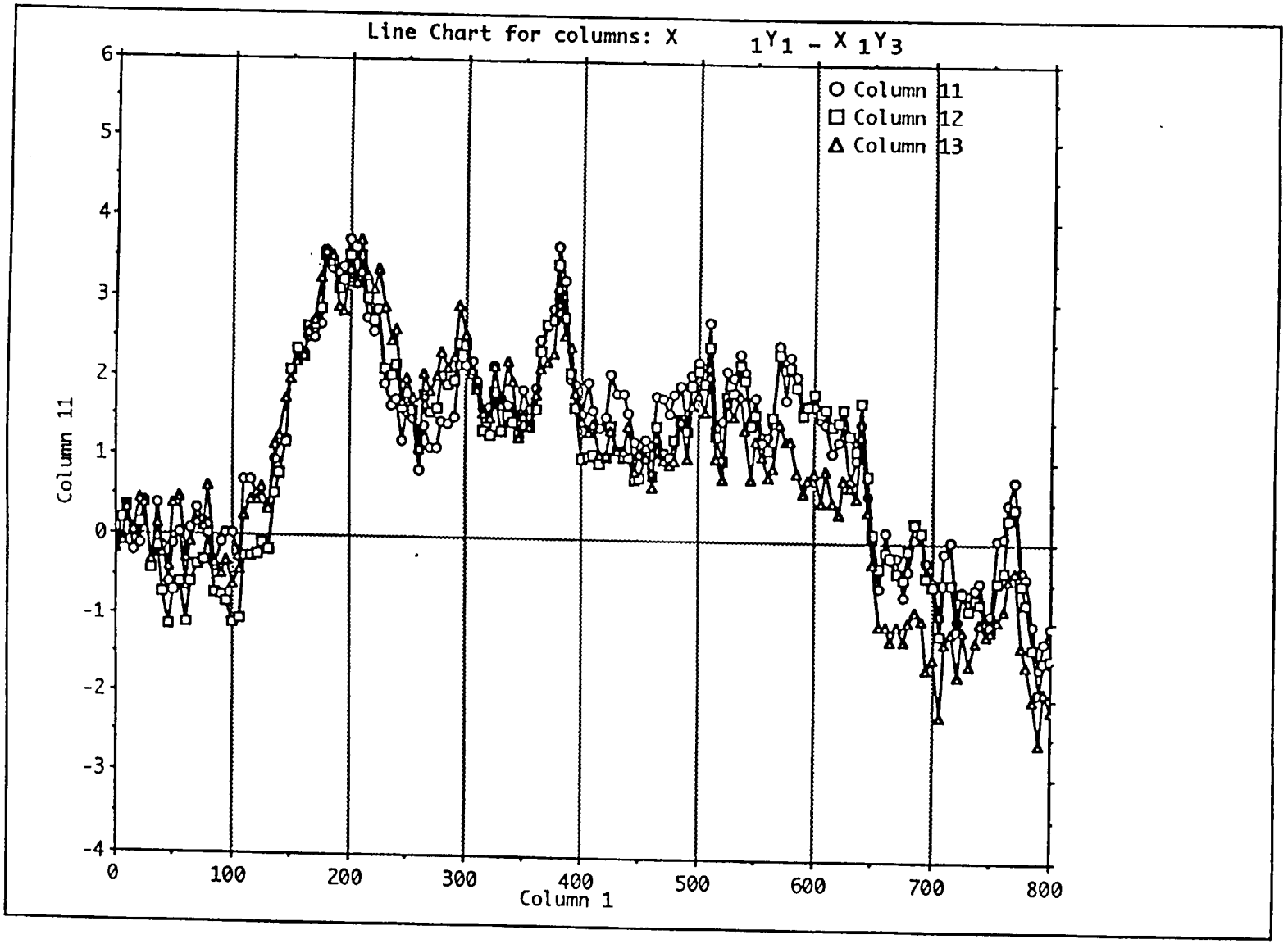
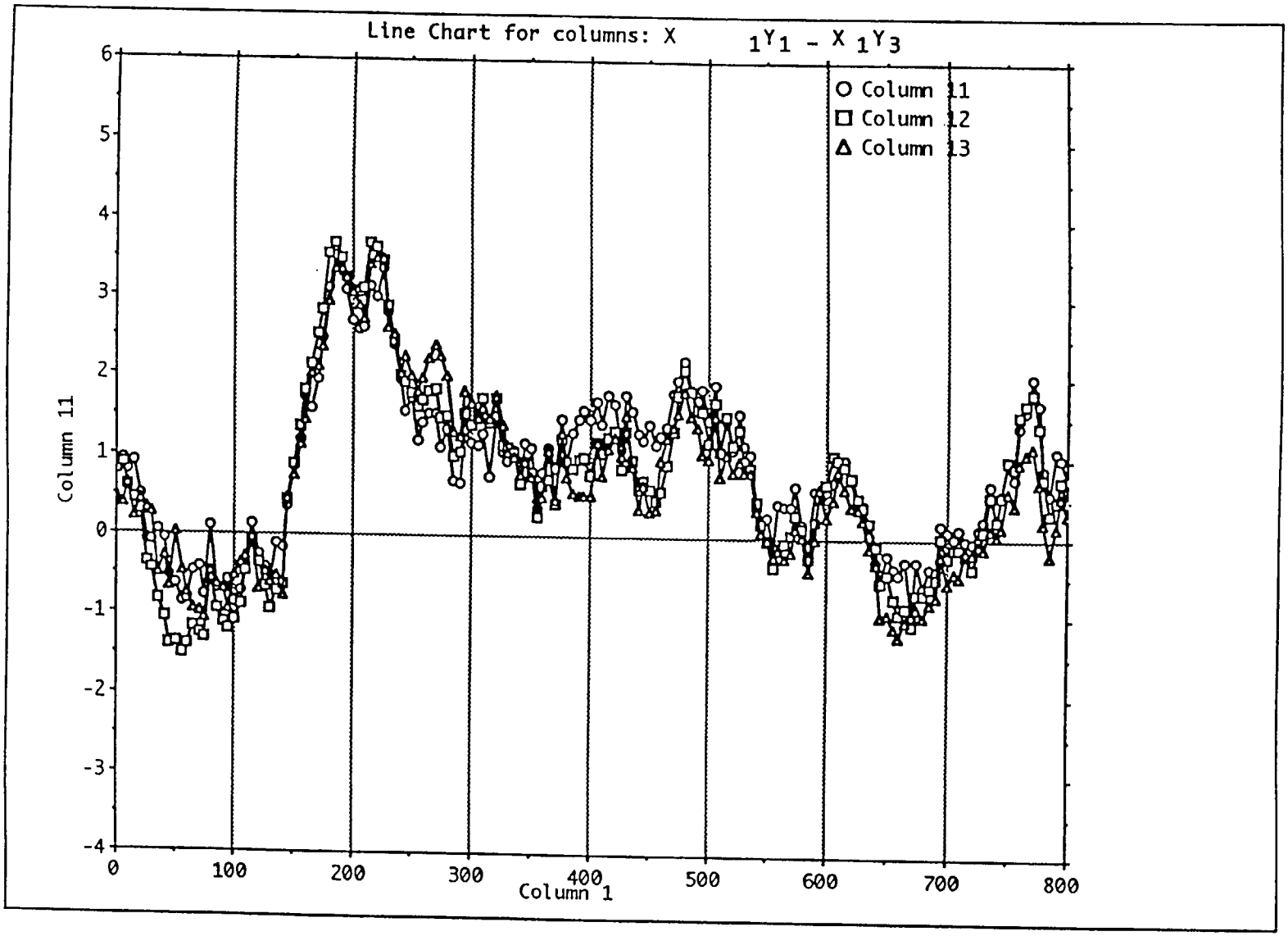


FIG 8

Depressed No Laugh (n=152)



examination of state-related brain maps representing conditions of various electrical waves (alpha, beta, delta, and theta) over periods of several seconds as influenced by activities requiring several minutes. The second was the investigation of event-related potentials, waves of activity measured in hundredths of milliseconds, which are triggered by instantaneous stimuli. In the present project, the second line of investigation was most productive.

The manipulation of positive and negative affective states did not result in consistent or significant changes in the brain maps of our subjects. The subsequent activity of responding to incongruous verbal material also had little generalizable effect in the long-term brain activity. Although some consistencies have been revealed by within-electrode comparisons, individual differences make the general interpretation difficult. It is not surprising that brain maps are so idiosyncratic given the correspondent individuality in complex information processing (Block & Null, 1985). It is apparent that long-term changes in brain maps are quite personality specific, and perhaps require more dramatic, active manipulations than the passive verbal techniques used here. The imagery procedures of Hinrichs and Machleidt (1992) or Stenberg (1992) and the information processing tasks of

Pope and Bogart (1992) have been shown to be significantly and more constantly effective.

As for the results on event-related potentials, two interconnected finding appeared. First, when instructed to resolve an ambiguity, the "surprise", or N400 wave, appeared even if the stimulus itself was unambiguous. Second, without such instructions, the N400 wave appeared only if an incongruity elicited the appropriate zygomatic reflex. Active information processing leads to a double-check on all significant events. Information processed passively is double-checked only if the incongruity is appreciated. Hazardous mental states must be those associated with passive information processing.

Proposal for continued research

The phenomena discovered and suggested by this research should be explored with improved procedural controls. The active-passive dichotomy in "double-checking" for incongruity can be extended to other, more clearly flight-related simulations. The positive-negative affect differences in the amount and latency or double-check (N400) responses should be studied, again with more dynamic manipulations of these mental states.

The experimental procedures can also be made more flight-specific and comparable to actual in flight

information-processing situations. In the original proposal, suggestions were made for the use of complex but repetitive (recursive) and structured but probabilistic (stochastic) pattern recognition tasks. The simulation situations available in the human engineering lab at NASA-Langley are ideal for such programs. Furthermore, verbal interpretations of visual material can give a more precise event-marker for evaluating event related potentials. The potential incongruities could take at least two forms. First, the visually presented material could be ambiguous, with the response indicating appreciation and resolution of the incongruity. Second, the verbal label could be incongruous with the visual material, requiring resolution of the existing incongruity. A recent extensive scaling study has categorized such a set of pictures and labels by the extent to which incongruities are introduced and resolved (Derks & Staley, in progress). In both experimental situations, the pictures presentation would set the stage for active or passive information processing and the verbal label or response would mark the initiation of the event related potential measure.

As for the affective manipulations, the Pope and Bogart (1992) procedures would be continued as well as the imaginal manipulations that have been reported

effective by other investigators. To cover all conditions within subjects, at least four sessions would be necessary (positive-active, negative-active, positive-passive, and negative-passive). Consequently, an important addition to this research would be off-site pretesting of subjects to avoid collecting data from individuals with high artifact electroencephalographic activity.

A proposed budget and justification is presented in appendix 6.

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Author Notes

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Table 1

Discriminant analysis of affective state EEG (in %).

	neg	before	pos
neg	49	21	30
before	11	34	4
pos	20	5	33

prior prob. = 33%, $X^2(4) = 64.28$, $p < .0001$

Table 2

Effect of Affective State on Zygomatic Response to Incongruity

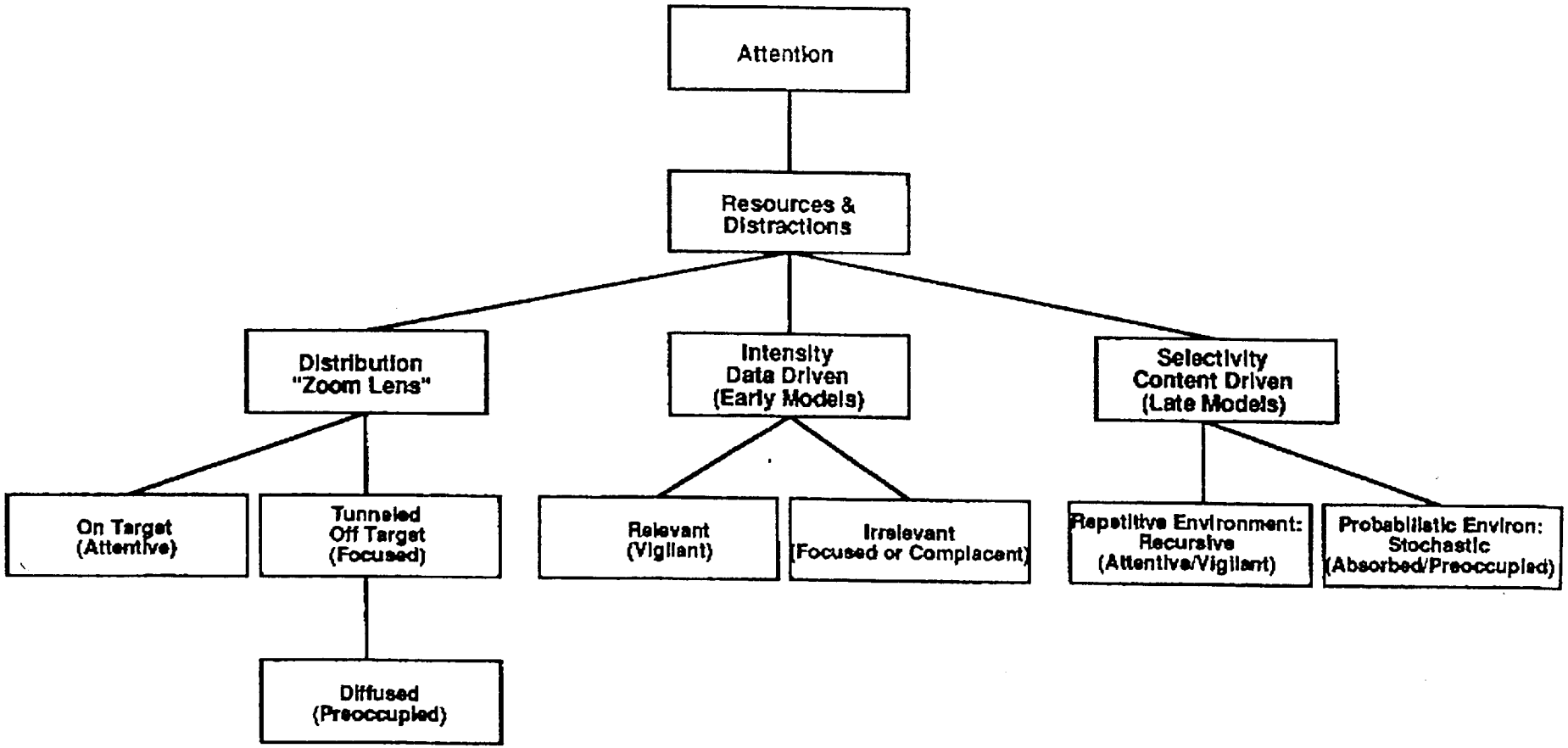
	Positive	Negative
Frequency	36%	30%
Intensity		
Post/Pre	93.89/54.03	50.59/33.28
Ratio	1.73	1.51

Appendix 1. summary outline of overall approach

Behavioral and Electroencephalographic Response to Incongruity (Fault Detection) and Incongruity Resolution (Fault Repair)

Cognitive Science Group
College of William and Mary

Problem


Attention
Resources & Distractions
Distribution "Zoom Lens"
Intensity Data Driven (Early Models)
Selectivity Content Driven (Late Models)
On Target (Attentive)
Tunneled Off Target (Focused)
Relevant (Vigilant)
Irrelevant (Focused or Complacent)
Repetitive Environment: Recursive (Attentive/Vigilant)
Probabilistic Environ: Stochastic (Absorbed/Preoccupied)
Diffused (Preoccupied)

Apparatus

Multi-Attribute Task Battery/ EMACS

System Monitoring

F1-F4 = Event sequence
F5 = System signal (Fault)
F6 = Response feedback (Fault repair)

Tracking

Response to system signal: digital or analog

Scheduling, pump status, etc.

Potential distractors

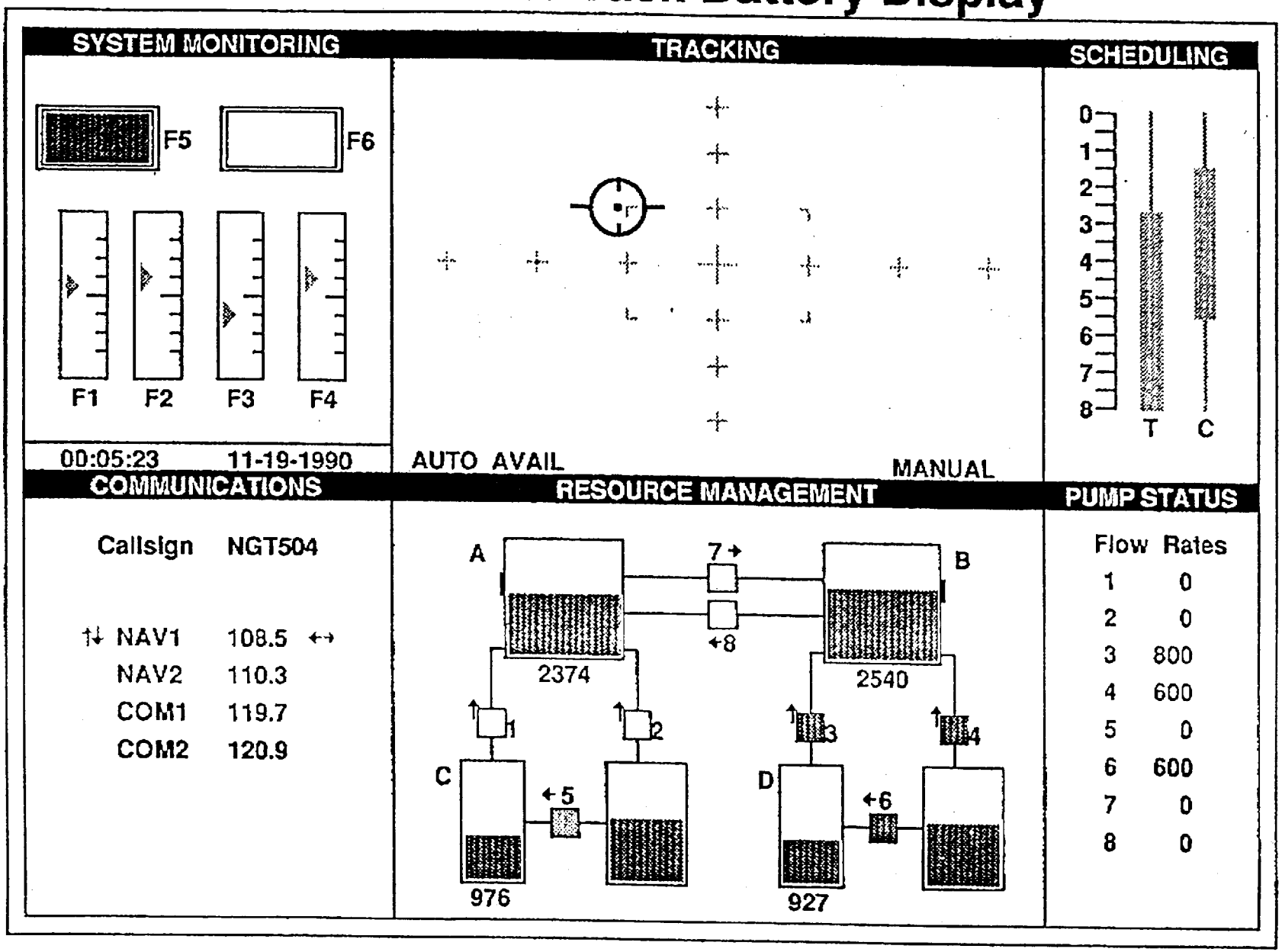
Cadwell Electroencephalograph

Short term event-related potential (ERP)

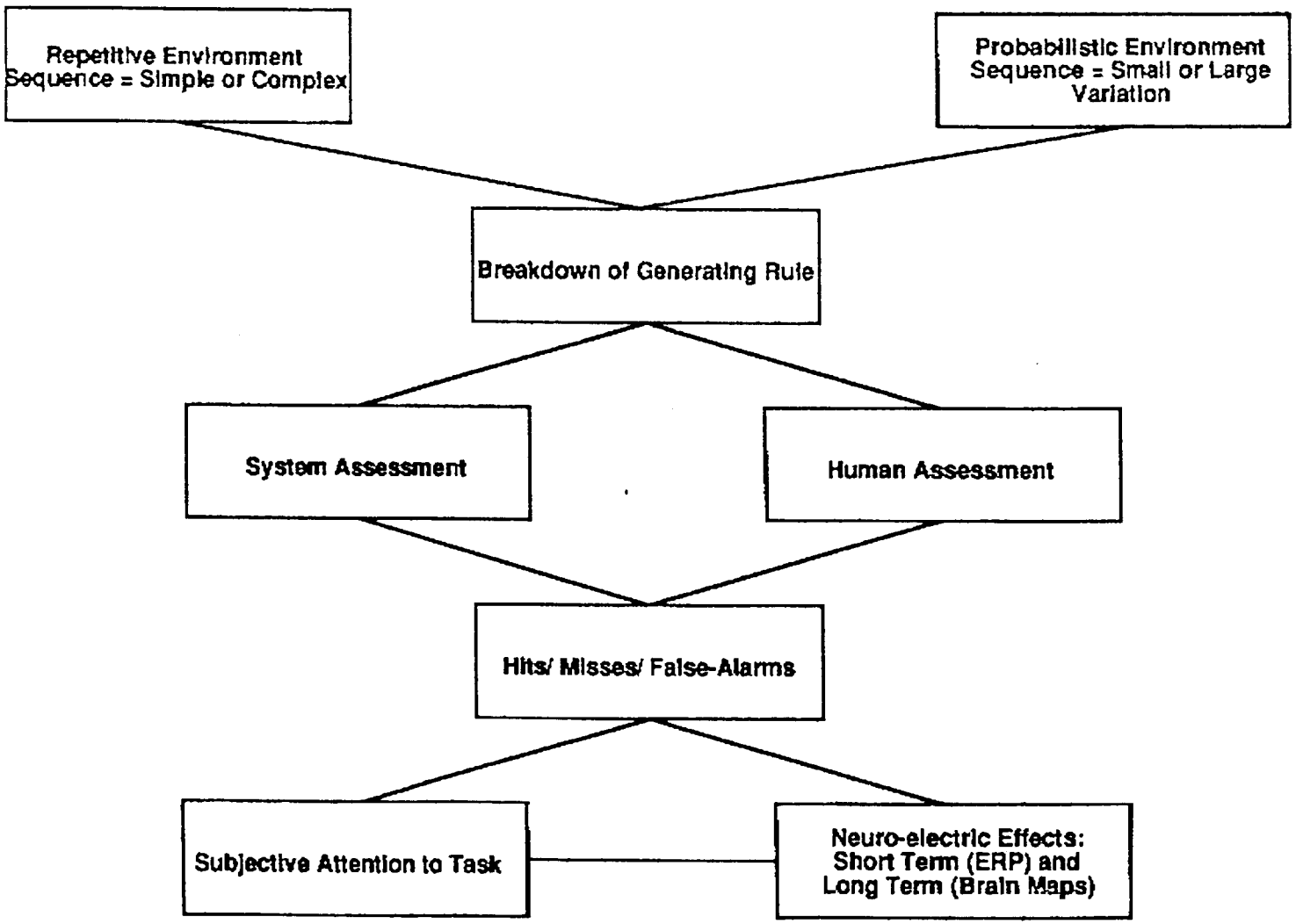
P300 = Attention
N400 = Incongruity

Long term brain map of mental states

Multi-Attribute Task Battery Display



Manipulations



Experiments

A. Pattern and Incongruity (Fault)

1. Repetitive or probabilistic pattern of F1-F4 activity
   a. Distributions, intensities, complexities
   b. Change in pattern: slight –> extreme

2. Brain map: mental state
   Event-related potential: attention

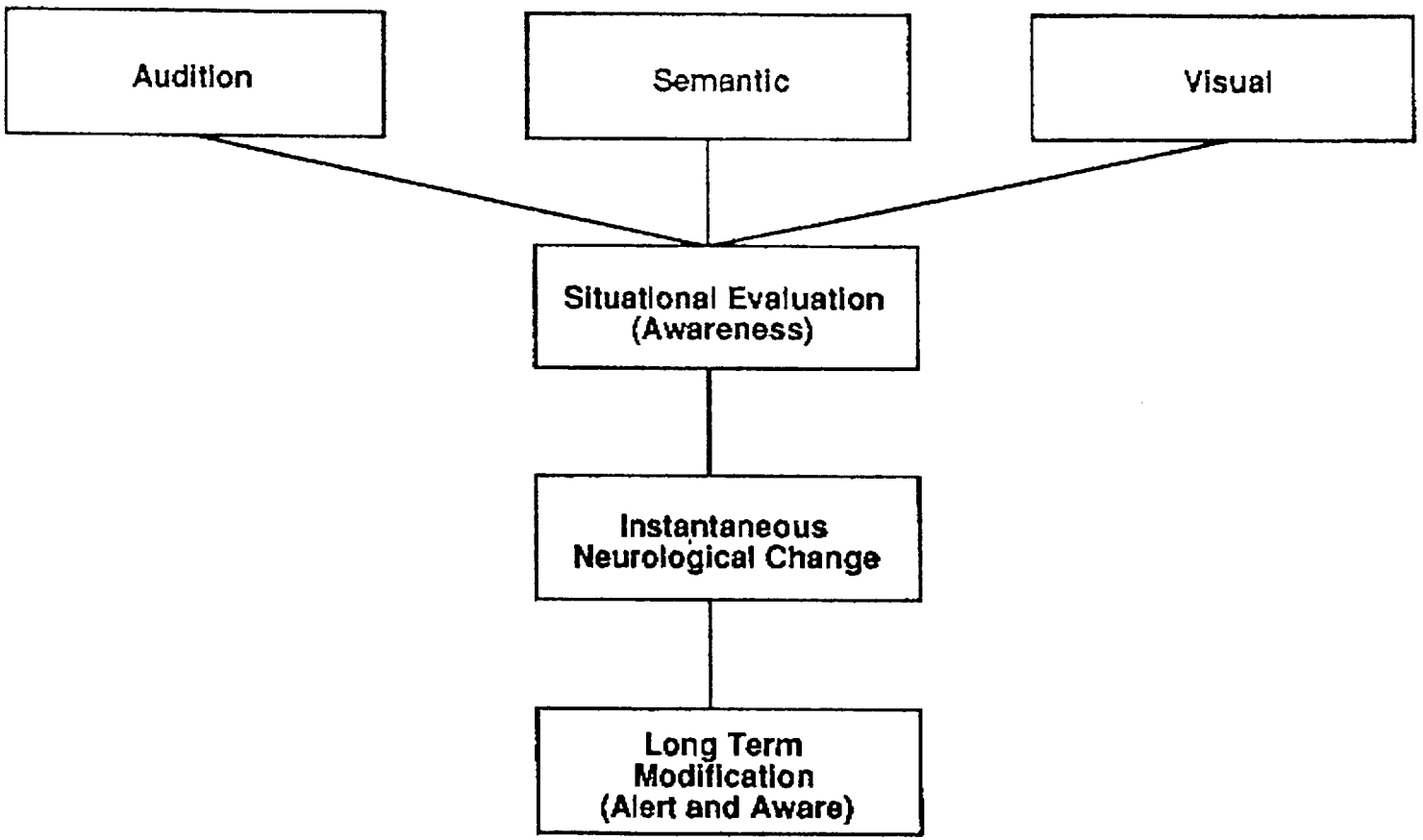
B. System/Human Match

1. As in A. (pattern and incongruity)
2. F5 signals change (fault)
3. Tracking change performed
4. F6 signals success of change (fault resolution)
   a. Ratios of agreement: F5/F6
      1/1 = hit
      > 1/1 = miss
      1/>1 = false alarm
   b. Incongruity (signal or fault detection) and event-related potential

C. Analogous Procedures

1. Pictoral stimuli: ambiguous figures and resolution
2. Auditory stimuli: music and "sour notes"
3. Verbal stimuli: semantic patterns (sentences) and incongrous elements (ambiguous or inappropriate words)
   i.e. "garden path" messages, metaphors, jokes

Product


Audition
Semantic
Visual
Situational Evaluation (Awareness)
Instantaneous Neurological Change
Long Term Modification (Alert and Aware)

1. Measures of mental states analogous to real world incongruity (faults) and its resolution (fault repair)

2. Determination of role of computational fault detection in mental monitoring and resolution of system

3. Determination of generality across modalities

Appendix 2. nouns, verbs, and ambiguous words with subjective ratings (1=noun, 5=verb)

NOUNS				VERBS	
cow	1.000	queen	1.400	like	4.333
cup	1.733	straw	1.000	reach	4.000
fruit	1.000	cat	1.067	fail	4.933
house	1.867	pie	1.000	pour	4.667
job	1.000	pole	1.400	dry	4.267
meal	1.133	pond	1.000	shoot	4.600
pipe	1.533	rice	1.000	hide	4.000
pool	2.000	truth	1.000	think	4.933
silk	1.000	card	1.667	burst	4.000
shirt	1.133	globe	1.200		
bone	1.333	tin	1.000		
dirt	1.267	truck	1.733		
door	1.267	snake	1.867		
aunt	1.000				
cheese	1.400				
class	1.200				
fact	1.000				
mice	1.000				
task	1.400				
blank	2.000				
chest	1.067				
day	1.000				
lake	1.000				
lip	1.400				
mouse	1.200				
pine	1.933				

AMBIGIOUS

cave	2.333	march	3.133	hope	3.267
date	3.000	miss	3.733	slide	3.000
hold	3.533	move	3.600		
knot	2.714	pet	2.800		
lift	3.533	play	3.067		
log	2.200	rise	3.933		
pass	3.200	train	2.733		
pile	2.867	bank	2.200		
pitch	3.200	bend	3.800		
pound	2.800	graph	3.000		
press	3.333	leaf	2.267		
rule	3.067	roll	3.067		
sail	3.133	stream	2.467		
shell	2.267	club	2.400		
sound	2.667	deck	2.467		
store	3.000	plant	2.867		
tie	3.067	bark	3.000		
touch	3.400	call	3.200		
track	2.933	drop	3.533		
cap	2.571	knee	2.067		
chain	2.667	load	3.000		
cook	3.067	shade	2.867		
dream	3.000	aid	3.067		
duck	2.800	blow	3.733		
fix	3.800	cage	2.533		
oft	2.200	court	2.533		

Appendix 3. statements in Velten affect manipulation procedure

. PLEASE READ EACH OF THE FOLLOWING STATEMENTS TO YOURSELF. THEN READ EACH OF THE STATEMENTS OUT LOUD. BUT TO AVOID REPETITIOUSNESS, BEGIN WITH THE STATEMENTS BELOW THE LINE OF DASHES. AFTER YOU HAVE READ WHAT FOLLOWS TO YOURSELF, READ IT ALOUD.

WILL READ EACH OF THE FOLLOWING STATEMENTS TO MYSELF. THEN I WILL READ EACH OF THE STATEMENTS OUT LOUD, AND I WON'T WORRY ABOUT THE READING ERRORS WHICH OFTEN OCCUR IN UNFAMILIAR SITUATIONS.

. IN THE FIRST PART OF THIS EXPERIMENT, I WILL BE SHOWN A SERIES OF SCREENS WITH STATEMENTS ON THEM. THESE STATEMENTS REPRESENT A CERTAIN MOOD. MY SUCCESS WILL BE LARGELY A QUESTION OF MY WILLINGNESS TO BE RECEPTIVE AND RESPONSIVE TO THE IDEA IN EACH STATEMENT, AND TO ALLOW EACH IDEA TO ACT UPON ME WITHOUT INTERFERENCE. THESE IDEAS ARE CALLED SUGGESTIONS.

. FIRST, AS EACH STATEMENT IS PLACED BEFORE ME, I WILL SIMPLY READ IT TO MYSELF, AND THEN I WILL READ IT ONCE OUT LOUD IN A MANNER APPROPRIATE TO ITS INTENDED SERIOUSNESS. THEN I'LL GO OVER EACH STATEMENT AGAIN AND AGAIN IN MY HEAD WITH THE DETERMINATION AND WILLINGNESS TO REALLY BELIEVE IT. I WILL EXPERIENCE EACH IDEA. I WILL CONCENTRATE MY FULL ATTENTION ON IT. AND I WILL EXCLUDE OTHER IDEAS WHICH ARE UNRELATED TO THE MOOD------LIKE, "I'LL SEE IF THIS WILL WORK."

. I WILL ALWAYS ATTEMPT TO RESPOND TO THE FEELING SUGGESTED BY EACH ITEM. I WILL THEN TRY TO THINK OF MYSELF WITH AS MUCH CLARITY AND REALISM AS POSSIBLE AS DEFINITELY BEING AND MOVING INTO THAT MOOD STATE. I AM LETTING MYSELF BE RECEPTIVE TO THESE FEELINGS. DIFFERENT PEOPLE MOVE INTO MOODS IN DIFFERENT WAYS. WHATEVER INDUCES THE MOOD IN ME FASTEST AND MOST DEEPLY IS THE BEST WAY FOR ME. SOME PEOPLE SIMPLY REPEAT THE STATEMENTS OVER AND OVER AGAIN TO THEMSELVES WITH THE INTENTION OF EXPERIENCING THEM.

. SOME PEOPLE FIND IT NATURAL AND EASY FOR THEM TO VISUALIZE A SCENE IN WHICH THEY HAD OR WOULD HAVE HAD SUCH A FEELING OR THOUGHT. OR, PERHAPS SOME EASY COMBINATION OF REPEATING THE STATEMENTS AND IMAGINING SCENES WILL COME TO ME. VERY LIKELY, I WILL BEGIN TO FEEL THE WAY I DO WHEN I'M IN THAT MOOD. I WILL CONTINUE TO CONCENTRATE MY FULL CONSCIOUSNESS ON EXPERIENCING AND RETAINING THE MOOD AS THE EXPERIMENTER PRESENTS EACH SUGGESTION. A CERTAIN AMOUNT OF TIME WILL BE DEVOTED TO EACH SUGGESTION. I WILL CONTINUE TO DISCIPLINE AND TRAIN MYSELF IN INDUCING A MOOD IN MYSELF BY CONCENTRATING MY FULL ATTENTION ON THE MOOD-STATEMENTS DURING ANY TIME INTERVAL.

. TO SUM UP: THE WHOLE PURPOSE OF THIS EXPERIMENT IS TO SEE WHETHER A PERSON CAN TALK HIMSELF INTO A MOOD. SOME OF THESE MOOD-STATEMENTS MAY HAVE NO RELATION TO ANYTHING I HAVE EVER THOUGHT, SAID OR DONE. YET, EXACTLY IN THE MANNER OF HYPNOSIS, I WILL FIND IT QUITE EASY TO ACCEPT AND FEEL THESE EMOTIONS. I WILL BE CONCENTRATING ON DOING SO, RATHER THAN COMPARING EACH SINGLE STATEMENT TO MY LIFE EXPERIENCE AND THEN DECIDING WHETHER IT APPLIES TO ME. I WILL LET AND STRIVE TO LET THEM APPLY TO ME. I CAN DO THIS.

7. I EXPERIENCE EACH STATEMENT AS IF IT WERE ESPECIALLY WRITTEN FOR ME. AT FIRST I MAY FEEL THE IMPULSE TO COMPARE A SINGLE MOOD-STATEMENT TO MY LIFE EXPERIENCE, OR TO RESIST STATEMENTS WHICH SEEM TO BE OR ARE CONTRADICTORY TO WHAT I FEEL MYSELF TO BE. BUT, MOST PEOPLE FEEL THIS AT FIRST. IT WILL BECOME APPARENT TO ME THAT IF I AM ABLE TO TALK MYSELF INTO A MOOD, THEN OBVIOUSLY I KNOW HOW TO TALK MYSELF OUT OF ONE. IF I FIND THAT I CAN DO THESE THINGS, THEN I HAVE LEARNED SOMETHING VALUABLE ABOUT MYSELF: I CAN LEARN TO CONTROL MY MOODS TO AN EXTENT.

8. IF I FEEL THE URGE TO LAUGH, IT WILL PROBABLY BE BECAUSE HUMOR IS A GOOD WAY TO COUNTERACT UNWANTED FEELINGS------OR, IT MIGHT BE BECAUSE I AM SURPRISED THAT I REALLY AM GOING INTO THE MOOD. I WILL TRY TO AVOID THESE REACTIONS, HOWEVER, BY KEEPING IN MIND THAT I HAVE THE CHANCE OF ACQUIRING EXTREMELY USEFUL INFORMATION ABOUT MYSELF AND HOW TO HELP MYSELF OUT OF UNDESIRABLE MOODS THAT OCCUR IN EVERYDAY LIFE. IF FOR ANY REASON I FEEL I CANNOT CONTINUE, I WILL SO INDICATE.

. TODAY IS NEITHER BETTER NOR WORSE THAN ANY OTHER DAY

2. I DO FEEL PRETTY GOOD TODAY, THOUGH

. I FEEL LIGHT-HEARTED

4. THIS MIGHT TURN OUT TO HAVE BEEN ONE OF MY GOOD DAYS

. IF YOUR ATTITUDE IS GOOD, THEN THINGS ARE GOOD, AND MY ATTITUDE IS GOOD

. I'VE CERTAINLY GOT ENERGY AND SELF-CONFIDENCE TO SPARE

7. I FEEL CHEERFUL AND LIVELY

. ON THE WHOLE, I HAVE VERY LITTLE DIFFICULTY IN THINKING

9. MY PARENTS ARE PRETTY PROUD OF ME MOST OF THE TIME

). I'M GLAD I'M IN COLLEGE------IT'S THE KEY TO SUCCESS NOWADAYS

'1. FOR THE REST OF THE DAY, I BET THINGS WILL GO REALLY WELL

I2. I'M PLEASED THAT MOST PEOPLE ARE SO FRIENDLY TO ME

3. MY JUDGMENT ABOUT MOST THINGS IS SOUND

4. IT'S ENCOURAGING THAT AS I GET FARTHER INTO MY MAJOR, IT'S GOING TO TAKE LESS STUDY TO GET GOOD GRADES

15. I'M FULL OF ENERGY AND AMBITION------I FEEL I COULD GO A LONG TIME WITHOUT SLEEP

16. THIS IS ONE OF THOSE DAYS WHEN I CAN GRIND OUT SCHOOLWORK WITH PRACTICALLY NO EFFORT AT ALL

17. MY JUDGMENT IS KEEN AND PRECISE TODAY

_8. WHEN I WANT TO, I CAN MAKE FRIENDS EXTREMELY EASILY

19. IF I SET MY MIND TO IT, I SCAN MAKE THINGS TURN OUT FINE

z0. I FEEL ENTHUSIASTIC AND CONFIDENT NOW

1. THERE SHOULD BE OPPORTUNITY FOR A LOT OF GOOD TIMES COMING ALONG

22. MY FAVORITE SONG KEEPS GOING THROUGH MY HEAD

3. SOME OF MY FRIENDS ARE SO LIVELY AND OPTIMISTIC

24. I FEEL TALKATIVE------I FEEL TALKATIVE------I FEEL LIKE TALKING TO ALMOST ANYBODY

5. I'M FULL OF ENERGY, AND AM REALLY GETTING TO LIKE THE THINGS I'M DOING ON CAMPUS

26. I'M ABLE TO DO THINGS ACCURATELY AND EFFICIENTLY

27. I KNOW GOOD AND WELL THAT I CAN ACHIEVE THE GOALS I SET

8. NOW THAT IT OCCURS TO ME, MOST OF THE THINGS THAT HAVE DEPRESSED ME WOULDN'T HAVE IF I'D JUST HAD THE RIGHT ATTITUDE

9. I HAVE A SENSE OF POWER AND VIGOR

30. I FEEL SO VIVACIOUS AND EFFICIENT TODAY------SITTING ON TOP OF THE WORLD

31. IT WOULD REALLY TAKE SOMETHING TO STOP ME NOW!

2. IN THE LONG RUN, IT'S OBVIOUS THAT THINGS HAVE GOTTEN BETTER AND BETTER DURING MY LIFE

3. I KNOW THAT IN THE FUTURE I WON'T OVER-EMPHASIZE SO-CALLED "PROBLEMS"

34. I'M OPTIMISTIC THAT I CAN GET ALONG VERY WELL WITH MOST OF THE PEOPLE I MEET

35. I'M TOO ABSORBED IN THINGS TO HAVE TIME FOR WORRY

6. I'M FEELING AMAZINGLY GOOD TODAY!

37. I AM PARTICULARLY INVENTIVE AND RESOURCEFUL IN THIS MOOD

8. I FEEL SUPERB! I THINK I CAN WORK TO THE BEST OF MY ABILITY

39. THINGS LOOK GOOD

40. I FEEL THAT MANY OF MY FRIENDSHIPS WILL STACK WITH ME IN THE FUTURE

41. I CAN FIND THE GOOD IN ALMOST ANYTHING

42. I FEEL SO HAPPY AND PLAYFUL TODAY I FEEL LIKE SURPRISING SOMEONE BY TELLING A SILLY JOKE

43. I FEEL AN EXHILARATING ANIMATION IN ALL I DO

44. I FEEL HIGHLY PERCEPTIVE AND REFRESHED

45. MY MEMORY IS IN RARE FORM TODAY

46. IN A BUOYANT MOOD LIKE THIS ONE, I CAN WORK FAST AND DO IT RIGHT THE FIRST TIME

47. I CAN CONCENTRATE HARD ON ANYTHING I DO

48. MY THINKING IS CLEAR AND RAPID

49. LIFE IS SO MUCH FUN; IT SEEMS TO OFFER SO MANY SOURCES OF FULFILLMENT

50. THINGS WILL BE BETTER AND BETTER TODAY

51. I CAN MAKE DECISIONS RAPIDLY AND CORRECTLY; AND I CAN DEFEND THEM

AGAINST CRITICISM EASILY

52. I FEEL INDUSTRIOUS AS HECK------I WANT SOMETHING TO DO!

53. LIFE IS FIRMLY IN MY CONTROL

54. I WISH SOMEBODY WOULD PLAY SOME GOOD LOUD MUSIC!

55. THIS IS GREAT------I REALLY DO FEEL GOOD I AM ELATED ABOUT THINGS

56. I'M REALLY FEELING SHARP NOW

57. THIS IS JUST ONE OF THOSE DAYS WHEN I'M READY TO GO!

58. I FEEL LIKE BURSTING WITH LAUGHTER------I WISH SOMEBODY WOULD TELL A JOKE AND GIVE ME AN EXCUSE!

59. I'M FULL OF ENERGY

60. GOD, I FEEL GREAT!

→→→→→→→→→→→→→→→→→→→→

1. TODAY IS NEITHER BETTER NOR WORSE THAN ANY OTHER DAY

2. HOWEVER, I FEEL A LITTLE LOW TODAY

3. I FEEL RATHER SLUGGISH NOW

4. SOMETIMES I WONDER WHETHER SCHOOL IS ALL THAT WORTHWHILE

5. EVERY NOW AND THEN I FEEL SO TIRED AND GLOOMY THAT I'D RATHER JUST SIT THAN DO ANYTHING

6. I CAN REMEMBER TIMES WHEN EVERYBODY BUT ME SEEMED FULL OF ENERGY

7. TOO OFTEN I HAVE FOUND MYSELF STARING LISTLESSLY INTO THE DISTANCE, MY MIND A BLANK, WHEN I DEFINITELY SHOULD HAVE BEEN STUDYING

8. IT HAS OCCURRED TO ME MORE THAN ONCE THAT STUDY IS BASICALLY USELESS, BECAUSE YOU FORGET ALMOST EVERYTHING YOU LEARN ANYWAY

9. PEOPLE ANNOY ME; I WISH I COULD BE BY MYSELF

10. I'VE HAD IMPORTANT DECISIONS TO MAKE

11. I DO FEEL SOMEWHAT DISCOURAGED AND DROWSY--MAYBE I'LL NEED A NAP WHEN I GET HOME

12. PERHAPS COLLEGE TAKES MORE TIME, EFFORT, AND MONEY THAN IT'S WORTH

13. I'M AFRAID THE WAR IN THE PERSIAN GULF MAY GET A LOT WORSE

14. I JUST DON'T SEEM TO BE ABLE TO GET GOING AS FAST AS I USED TO

15. THERE HAVE BEEN DAYS WHEN I FELT WEAK AND CONFUSED, AND EVERYTHING WENT MISERABLY WRONG

16. JUST A LITTLE BIT OF EFFORT TIRES ME OUT

17. I'VE HAD DAYDREAMS IN WHICH MY MISTAKES KEPT OCCURRING TO ME----SOMETIMES I WISH I COULD START OVER AGAIN

18. I'M ASHAMED THAT I'VE CAUSED MY PARENTS NEEDLESS WORRY

19. I FEEL TERRIBLY TIRED AND INDIFFERENT TO THINGS TODAY

20. JUST TO STAND UP WOULD TAKE A BIG EFFORT

21. I'M GETTING TIRED OUT I CAN FEEL MY BODY GETTING EXHAUSTED AND HEAVY

22. I'M BEGINNING TO FEEL SLEEPY MY THOUGHTS ARE DRIFTING

23. AT TIMES I'VE BEEN SO TIRED AND DISCOURAGED THAT I WENT TO SLEEP RATHER THAN FACE IMPORTANT PROBLEMS

24. MY LIFE IS SO TIRESOME---THE SAME OLD THING DAY AFTER DAY DEPRESSES ME

25. I COULDN'T REMEMBER THINGS WELL RIGHT NOW IF I HAD TO

26. I JUST CAN'T MAKE UP MY MIND; IT'S SO HARD TO MAKE SIMPLE DECISIONS

27. I WANT TO GO TO SLEEP------I FEEL LIKE JUST CLOSING MY EYES AND GOING TO SLEEP RIGHT HERE

28. I'M NOT VERY ALERT; I FEEL LISTLESS AND VAGUELY SAD

29. I'VE DOUBTED THAT I'M A WORTHWHILE PERSON

30. I FEEL WORN OUT MY HEALTH MAY NOT BE AS GOOD AS IT'S SUPPOSED TO BE

31. IT OFTEN SEEMS THAT NO MATTER HOW HARD I TRY, THINGS STILL GO WRONG

32. I'VE NOTICED THAT NO ONE SEEMS TO REALLY UNDERSTAND OR CARE WHEN I COMPLAIN OR FEEL UNHAPPY

33. I'M UNCERTAIN ABOUT MY FUTURE

34. I'M DISCOURAGED AND UNHAPPY ABOUT MYSELF

35. I'VE LAIN AWAKE AT NIGHT WORRYING SO LONG THAT I HATED MYSELF

36. THINGS ARE WORSE NOW THAN WHEN I WAS YOUNGER

37. THE WAY I FEEL NOW, THE FUTURE LOOKS BORING AND HOPELESS

38. MY PARENTS NEVER REALLY TRIED TO UNDERSTAND ME

39. SOME VERY IMPORTANT DECISIONS ARE ALMOST IMPOSSIBLE FOR ME TO MAKE

40. I FEEL TIRED AND DEPRESSED; I DON'T FEEL LIKE WORKING ON THE THINGS I KNOW I MUST GET DONE

41. I FEEL HORRIBLY GUILTY ABOUT HOW I'VE TREATED MY PARENTS AT TIMES

42. I HAVE THE FEELING THAT I JUST CAN'T REACH PEOPLE

43. THINGS ARE EASIER AND BETTER FOR OTHER PEOPLE THAN FOR ME I FEEL LIKE THERE'S NO USE IN TRYING AGAIN

44. OFTEN PEOPLE MAKE ME VERY UPSET I DON'T LIKE TO BE AROUND THEM

45. IT TAKES TOO MUCH EFFORT TO CONVINCE PEOPLE OF ANYTHING THERE'S NO POINT IN TRYING

46. I FAIL IN COMMUNICATING WITH PEOPLE ABOUT MY PROBLEMS

47. IT'S SO DISCOURAGING THE WAY PEOPLE DON'T REALLY LISTEN TO ME

48. I'VE FELT SO ALONE BEFORE, THAT I COULD HAVE CRIED

49. SOMETIMES I'VE WISHED I COULD DIE

50. MY THOUGHTS ARE SO SLOW AND DOWNCAST I DON'T WANT TO THINK OR TALK

51. I JUST DON'T CARE ABOUT ANYTHING LIFE JUST ISN'T ANY FUN

5 . LIFE SEEMS TOO MUCH FOR ME ANYHOW-----MY EFFORTS ARE WASTED

53. I'M SO TIRED

5 . I DON'T CONCENTRATE OR MOVE I JUST WANT TO FORGET ABOUT EVERYTHING

5 . I HAVE TOO MANY BAD THINGS IN MY LIFE

56. EVERYTHING SEEMS UTTERLY FUTILE AND EMPTY

57. I FEEL DIZZY AND FAINT I NEED TO PUT MY HEAD DOWN AND NOT MOVE

5 . I DON'T WANT TO DO ANYTHING

59. ALL OF THE UNHAPPINESS OF MY PAST LIFE IS TAKING POSSESSION OF ME

6 . I WANT TO GO TO SLEEP AND NEVER WAKE UP

Appendix 4. ambiguous messages with resolutions

Running into debt isn't so bad - what hurts is running into

creditors.

We were standing on a local corner near one of those penny scales when a husband and wife approached. He jumped on the scale and dropped in a penny. "Listen to this fortune," he said enthusiastically to his wife as she peered over his shoulder. "It says I'm bright, resourceful, energetic, romantic and that I will be a great success."
"Yeah," she returned, "it's also got your

weight wrong."

Phillis Diller says she decided to go on a diet the day she got married; "In fact, on our wedding night when my husband carried me over the threshold he had to make

two trips."

Did you ever notice that when you start a diet-the first thing you lose is

your temper?

Definition of a Father: The kin you love

to touch.

Definition of an Old Maid: A woman who's been good

for nothing.

I met the stingiest boss of all. You get in five minutes late and he docks your pay. You get in five minutes early and he charges you

rent."

Winning a lot of money at the race track is possible - even probable - but only if you're a

fast horse.

The girl walked into the drugstore and told the druggist she would like to buy some rat poison. "Would you like to take it with you?" the druggist asked. The girl replied: "No - I'll just send in

the rats."

He had such a big nose that he could smoke a cigar under

a shower.

The best part of a family tree is

underground.

W.C. Fields once said: "Anybody who hates dogs and children can't be

all bad."

In Orient when a woman walks behind her husband it means he's being respected. In America when a woman walks behind her husband it means he's being

tailed.

I once opened fortune cookie that said: "You will meet a beautiful redhead. You will give her money. She is

our cashier."

A good way for a husband to get the last word - is to

apologize.

Have you heard the old saying: A friend in need - is a

pest.

He's the kind of doctor who feels your

purse.

He's so dumb he lost his job as an elevator operator because he couldn't remember

the route.

There's a difference between a drunk and an alcoholic. The drunk doesn't have to go to

meetings.

Ice has great healing powers. It's a great pain reliever - especially when used in a glass of

scotch.

Did you ever stop to think that wrong numbers are never

busy?

A good ambassador won't take any side. In fact their favorite color should be

plaid.

I come from a very rough neighborhood - but they had a lot churches and synagogues around. One time I said to a priest friend of mine, "Is it true that around here if you carry a cross, you never have to worry?" He said, "Yes - if you carry it very

fast."

A little girl's prayer: "Please, God make the bad people good - and the good people

nice."

The great Albert Einstein once admitted that figuring out his income

tax was beyond him. "This is too difficult for a mathematician," he said. "What I need is a

philosopher."

I don't believe in pornography - I don't even have a

pornograph.

I know a couple, who found a plan that works. Three nights a week he goes out with the boys - the other four

she does.

If you have untold wealth - you can expect a visit from

the IRS.

The great Jascha Heifetz was giving a violin concert in Cleveland. The big hall was sold out, but because of the blizzard only 12 people showed. The gracious virtuoso walked on stage and said, "Thanks for coming, but there will be no concert performance tonight. You'll all get your money back." One man stood up in the audience and said, "Mr. Heifetz, I drove 200 miles in this storm to be here. At least

sing one song."

"I'm nuts about this girl," the 65-year-old banker confided to his friend at the club. "Do you think I have a better chance of marrying her if I tell her I'm fifty?" "I think you'll have a better chance if you tell her you're

eighty."

One pal of Groucho Marx' told him, "I don't drink, smoke or go after women and I just celebrated my 88th birthday." Groucho asked,

"How?"

"How could you let him get away?" the sergeant screamed at the rookie cop. "Did you watch all the exits like I told you?" "Yes, sir-but he must have left by one of the

entrances."

"The court will give you three good lawyers because of the importance of this case," the judge said. "If it's all the same to you, your Honor," the criminal said, "just get me one good

witness."

I come from a family of ten kids. I never knew what it was to sleep alone until I got

married.

I can resist anything but

temptation.

My aunt is a widow who is eighty-two years old. I arranged a date with her with a man of 86. She returned home from the date very late that evening a little upset. "What happened?" I asked. "Are you kidding?" she snapped. "I had to slap his face three times?" "You mean he got fresh?" "No - I thought he was

dead."

There's the Irishman who watches his health. He has Irish coffee that's

decaffeinated.

I think it was very nice of our founding fathers to sign the Declaration of Independence on

a holiday.

"My advice, sir," said the mechanic to the car owner, "is that you keep the oil and change the

car."

The mating computer at the resort hotel was particularly active that day. A tall handsome six footer stood in front of it and said, "I'm a millionaire, I have 12 oil wells and a gold mine, and I run 5 banks in Texas." So the computer

proposed.

Supervisor to Receptionist at Mental Hospital: "Please - just say we are very busy - not 'it's a

madhouse'."

Two friends were comparing letters from their kids in college. "When my son writes me, his letters send me to the dictionary," one father admitted. "You're lucky," said the other. "When my son writes me, his letters send me to

the bank."

The teacher wrote on the blackboard, "I ain't had no fun all summer." Then she asked her students, "What's wrong with the sentence and what do I do to correct it?" One kid in the back hollered. "Get

a boyfriend."

The hunter who was lost screamed at his guide: "You told me that you were the best guide in Vermont." The guide answered: "I am - but I think we're

in Canada."

"Tell me Charlie - how do you like school?"

"Closed"

TV is getting to be murder. You turn on the set and you see the worst

kind of violence, crime, degeneracy, murder and rape - and that's only

the news.

I always enjoy going up to see my stockbroker because he's ready for anything. At one end of his office there's a square device with a sign saying: "In Case of Emergency, Break Glass." It's a

window.

Running is when you use every muscle in your body. Incidentally, there are no muscles in the

brain.

We had our last car for 19 years. We grew so attached to it, we couldn't trade it in. We had to put it

to sleep.

The airlines think of everything. They've now made it possible for those of us who always wanted to go to Europe in the worst possible way to do so. It's called

standby.

As a weekend golfer, I have one all consuming ambition - to live to be 100. I've always wanted to shoot

my age.

You learn a a lot about reality from your kids. One of mine just bought a T-shirt that says: "The Best Things in Life Are Free." The shirt is

twelve bucks.

We have one of those color-coordinated homes: The roof is brown. The siding is brown. The garage is brown. Everything matches

the lawn.

When it comes to achievement, we really should give more credit to our Stone Age ancestors. Do you realize what cunning and strength it took to hunt dinosaurs? The decoy alone

weighed 3 tons!

Appendix 5. Neurological activity and incongruity: Preliminary observations of a brain during laughter. Peter L. Derks, Lynn S. Gillikin, and Edward H. Bogart (Preliminary report for NASA grant NCC1-160 is available from NASA-Langley, Hampton, VA. 23665).

Appendix 6. proposed budget and justification

PROPOSAL TO

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ON

INCONGRUITY, INCONGRUITY RESOLUTION, AND MENTAL STATES: THE MEASURE AND MODIFICATION OF SITUATIONAL AWARENESS AND CONTROL

from

Peter L. Derks and Lynn S. Gillikin
Department of Psychology
The College of William and Mary
Williamsburg, Virginia 23187

Amount Requested: $330,390

Project Period: October 1, 1993 - September 30, 1996

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THE COLLEGE OF WILLIAM AND MARY

Office of Grants and Research Administration

201 James Blair (804)221-4563 FAX: (804)221-1021

PROPOSAL TRANSMITTAL FORM

Date: 9/13/93

A. GENERAL INFORMATION

Principal Investigator/Project Director Peter L. Derks / Lynn S. Gilliken Telephone #: 221-3874 804-221-3814

Department or School Psychology

Title of Proposal Incongruity, Resolution, and Mental States

Sponsoring Agency NASA Langley DEADLINE: ____ Receipt Date/Postmark (circle one)

(Check one) Governmental: ✓ Federal/___ State ___ Non-governmental ___ Grant/___

Contract
New Project ___ or ✓ Continuation/Renewal of Grant/Contract No. NCC1-160

B. BUDGET INFORMATION

Total cost of project (including direct cost and indirect cost) $ 330,390. (3 years)

Direct cost requested from agency $ 76,700 (1yr) Indirect cost requested $ 29,130 (1 yr)

Release time $ ____ Summer salary $ ____ Student salary $ ____

College cost sharing $ ____ Type: (cash, PI's time, in-kind) ____

(CHECK ONE) Cost sharing by department ____ or Dean of School ____ (If Dean, obtain proper signature below.)

Project period begins Oct 1, 1993 and ends Sept 30, 1994

C. SPECIAL REQUIREMENTS (If any items are checked, obtain proper signature below.)

1. This proposal ✓ does ___ does not involve research with human subjects. If affirmative, date of committee review 4/91.
2. This proposal ___ does ✓ does not involve research with animals.
3. This proposal ___ does ✓ does not involve recombinant DNA.
4. This proposal ___ does ✓ does not involve conflict of interest.
5. Does this proposal assume University commitments beyond the grant period? ___ Yes ___ No

D. APPROVALS

	Signature	Date
* 1. Principal Investigator (PI)	Lynn Gilliken / Peter Derks	9/13/93
* 2. Department Chairperson		9/13/93
3. Dean		
4. Human Subjects Committee (S. Hoegerman 1-2240)		
5. Animal Welfare Committee (M. Roberts 642-7370)	N/A	
6. Conflict of Interest	N/A	

*Required on all proposals.

Rev. 1/93

PROPOSED BUDGET

Project Period Oct. 1, 1993 - Sept. 30, 1994

SALARIES AND WAGES	
Peter Derks, Professor	
20% time for 12 months	$15,920*
Lynn Gillikin, Adjunct Professor	
50% for 12 months	35,000**
Research Assistants (two)	
10 hrs./wk X 4.25 X 2 for School year	3,400
40 hrs/wk X 4.25 X 2 for Summer	3,400
Subjects	
40 @4hr @ $4.25	680
Total Salaries & Wages	58,400
FRINGE BENEFITS	
Social security on Derks (7.65%), GRA summer wages	1,220
Full fringe benefits on Gillikin (28%)	9,800
Total Fringe Benefits	11,020
EQUIPMENT (Cadwell Brain Mapper available from NASA)	-0-
Portable Hemispheric Activation Detector (two)	2,000
EXPENDABLE SUPPLIES	
Services at William and Mary	
Duplicating, floppy disks	
Telephone charges	500
OTHER COSTS	
Local travel (William and Mary to NASA), 1 round trip X 50 wks X 65 miles @$.24/mile = 3,250 miles X .24	780
Meals (lunch, 2 experimenters and subject), 150 x 8	1,200
Professional meetings, 2 X 2 people	2,800
Total Travel	4,780
TOTAL DIRECT COSTS	76,700
INDIRECT COSTS (39% of all but equipment, 74,700)	29,130
TOTAL PROJECT COSTS	$105,830

*Based on $79,600, an annualized salary of $61,300.
**Based on an hourly rate of approximately $33-34.

PROPOSED BUDGET (cont.)

Project Period Oct. 1, 1994 - Sept. 30, 1995

SALARIES AND WAGES	
Peter Derks, Professor	
20% time for 12 months	$17,160*
Lynn Gillikin, Adjunct Professor	
50% for 12 months	36,750**
Research Assistants (two)	
10 hrs./wk X 4.50 X 2 for School year	3,600
40 hrs/wk X 4.50 X 2 for Summer	3,600
Subjects	
40 @4hr @ $4.50	720
Total Salaries & Wages	61,830
FRINGE BENEFITS	
Social security on Derks (7.65%), GRA summer wages	1,310
Full fringe benefits on Gillikin (28%)	10,290
Total Fringe Benefits	11,600
EQUIPMENT (Cadwell Brain Mapper available from NASA)	-0-
EXPENDABLE SUPPLIES	
Services at William and Mary	
Duplicating, floppy disks	
Telephone charges	550
OTHER COSTS	
Local travel (William and Mary to NASA), 1 round trip X 50 wks X 65 miles @$.24/mile = 3,250 miles X .24	780
Meals (lunch, 2 experimenters and subject), 150 x 8	1,200
Professional meetings, 2 X 2 people	2,800
Total Travel	4,780
TOTAL DIRECT COSTS	78,760
INDIRECT COSTS (39% of 78,760)	30,720
TOTAL PROJECT COSTS	$109,480

*Based on $85,820, an annualized salary of $64,370.
**Based on an hourly rate of approximately $36-37.

PROPOSED BUDGET (cont.)

Project Period Oct. 1, 1995 - Sept. 30, 1996

SALARIES AND WAGES	
Peter Derks, Professor	
20% time for 12 months	$18,020*
Lynn Gillikin, Adjunct Professor	
50% for 12 months	38,590**
Research Assistants (two)	
10 hrs./wk X 4.50 X 2 for School year	3,600
40 hrs/wk X 4.50 X 2 for Summer	3,600
Subjects	
40 @4hr @ $4.50	720
Total Salaries & Wages	64,530
FRINGE BENEFITS	
Social security on Derks (7.65%), GRA summer wages	1,380
Full fringe benefits on Gillikin (28%)	10,800
Total Fringe Benefits	12,180
EQUIPMENT (Cadwell Brain Mapper available from NASA)	-0-
EXPENDABLE SUPPLIES	
Services at William and Mary	
Duplicating, floppy disks	
Telephone charges	600
OTHER COSTS	
Local travel (William and Mary to NASA), 1 round trip X 50 wks X 65 miles @$.24/mile = 3,250 miles X .24	780
Meals (lunch, 2 experimenters and subject), 150 x 10	1,500
Professional meetings, 2 X 2 people	3,200
Total Travel	5,480
TOTAL DIRECT COSTS	82,790
INDIRECT COSTS (39% of 78,760)	32,290
TOTAL PROJECT COSTS	$115,080
THREE YEAR PROJECT COST (93-96)	$330,390

*Based on $79,600, an annualized salary of $61,300.
**Based on an hourly rate of approximately $36-37.

Budget Justification

Peter Derks (Co-principal Investigator)

Professor Derks has studied cognition since before the term was popular. He received an M.A. from Harvard, where he studied under George Miller, and a Ph.D. from the University of Pennsylvania with Gene Galanter as his thesis advisor. His work on pattern recognition has been supported by a NASA grant No. NGL-47-006-008G. More recently he has been studying incongruity and incongruity resolution in the form of humor. He is on the editorial board of HUMOR: International Journal of Humor Studies.

Lynn Gillikin (Co-principal Investigator)

Professor Gillikin began studying neuropsychology when it was still called physiological psychology. She received M.A. and Ph.D. degrees from the University of Virginia in experimental psychology with a specialty in human learning and memory. She is a licensed psychologist, and Fellow and Diplomate of the American Board of Medical Psychotherapy. Teaching experience includes the University of Delaware as well as the College of William and Mary. Most recent position was Director of Psychology at the Riverside Rehabilitation Institute.

Research Assistants

The analysis of the data collected from a three hour EEG run takes approximately fifteen hours to analyze. Student aids will be necessary to assist in data analysis, subject testing, and literature search and acquisition.

Subjects

Some subjects will be recruited from the College of William & Mary and paid at the current rate for student assistants. Their time will include transportation to and from the laboratory at NASA-Langley.

Equipment

The hemispheric activation level detector is a portable device to pre-test candidates to avoid participants with excessive artifacts in their brain maps.

Expendable Supplies

Much of the administrative and secretarial activity will be carried out at the College of William & Mary and will require some purchases and services over the indirect costs.

Other Costs

Local Travel - The principal investigators will need to travel to NASA-Langley to supply transportation for subjects and to consult and perform the research.

Professional Travel - The principal investigators will communicate the results of the research at either two national meetings or, given the nature of the research, one international meeting. Psychophysiological conferences are frequently held in foreign countries (1992-Paris, France; 1993-Luxembourg).

Indirect Cost

This percentage has recently been arbitrated with the federal government.