ANALYSIS OF COGNITIVE COMPONENTS OF MEMORY DURING STRESS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM

The research and theorizing generated by the experimental investigation of learning in psychological laboratories has been followed by an application of learning principles to the study of psychopathology and the development of new therapies. The consequences, in great measure, have been enthusiasm, satisfaction, and some degree of success (e.g. Wolpe, 1967). Since human existence has many activities besides learning that involve higher-order brain functioning, it is not unexpected to see clinical psychology expressing rather deep interest in such processes as cognition, perception, and memory. Clinical practice and general observation have always suggested that most of these activities are inhibited, retarded, or otherwise disadvantageously affected by strong affective states such as anxiety or stress. Unfortunately, it is easier to form impressions than it is to design definitive empirical examinations, and thus clinical psychology has been burdened with vague, unmeasurable concepts such as repression, suppression, pre-socratic thought, cognitive slippage, schizoid thinking, etc. Maybe such concepts are illustrative or descriptive, but they are imprecise and difficult to define for experimental purposes.

Perhaps experimentation dealing with relationships between emotional and complex psychological processes is in a rudimentary stage, but it is nonetheless suggestive and encouraging. Primarily, studies have shown that strong negative emotional states altenuate performance on such tasks as memory, learning, perceptual, problem-solving, and intelligence tests. As some of these studies are reviewed there will be a repeated observation that the complex behavior under investigation is really a concept that directs attention to the eventual output of a series of events. For example, if during a stressful state, subjects are exposed to a list of words which they are asked to recall later, what is being tested, memory or learning?

C. L. Hull (1917) pointed out more than half a century ago in his study of the insane, that the concept of "memory" was much too vague in meaning for the psychologist. Inglis (1970) added that the concept involved several events:

> It has long been recognized that this sequence involves at least the three phases broadly labeled registration, retention, and retrieval. The disturbance of any one of these stages might lead to the impairment of the product usually called memory (p. 95).

Spokesmen from extremely divergent schools of psychology have postulated that retrieval is the stage that is impaired by an aversive state of affairs, and that this is of chief concern in the study of psychopathology. Freud (1925) said that man's memory is most perfect and that imperfect recall was the result of suppression or repression, and in spite of a lack of conscious awareness of this

information, it would continue to influence behavior. Wolpe (1967) postulated that pervasive anxiety, for which the patient has no explanation, is the result of conditioning to unclearly defined stimuli during an unpleasant experience. Thus, both suggest there is faulty retrieval of registered and retained information.

For the most part, however, psychopathologists have not attended to the efforts of their counterparts in the field of experimental psychology. Here the discussion involves different types of memories, for example, short-term and long-term memory (Waugh and Norman, 1965). Experimenters have also taken an interest in what it means when someone fails to remember. Brown (1958) suggests that memory traces associated with the forgotten information has decayed. Waugh and Norman (1965) propose the possibility that items stored earlier are displaced by subsequent items. In both cases, the trace is no longer available and therefore is impossible to "find." On the other hand, it is possible that there has been a trace of the item stored, but for reasons unknown or at least poorly understood, this trace cannot be retrieved. Recent research by a number of investigators (Allen, 1968; Allen, 1969; Lewis, 1971; Slamecka, 1968; Tulving and Pearlstone, 1966; Tulving and Psotka, 1971) has been directed toward this alternative. The distinction is made between traces that are <u>accessible</u> and traces that are <u>available</u>. Accessible refers to items which are freely recalled, and available refers to possible intact memory traces which are not freely recalled. Tulving and Pearlstone (1966) point out that

measures of retention such as unaided recall and recognition support "the proposition that unaided recall does not tap all the information that is available about previously learned material." They also recognize that the task differences between recognition and recall make comparisons difficult and only partially relevant. Another method was designed and tested, comparing free recall and cued recall. Subjects learned on a single trial lists of words belonging to verbally designated conceptual catagories. For instance, the catagory name "four-footed animals" was followed by cow and rat. Immediate recall was tested either in the presence or absence of category names as retrieval cues. Cued recall was higher than noncued recall. All subjects were administered a second recall test under the condition of cued recall. Subjects who experienced cued recall on both tests did almost equally well. There was no evidence of any forgetting or reminiscence. The subjects who first had been tested under the nonclued recall condition did significantly better, though not quite as well as the originally cued recall subjects; perhaps the result of the delay of response.

By viewing together some of the elements discussed above some interesting perceptions develop. For example, Freud said information which is especially stressing is often repressed, which makes this information difficult or impossible to tap even though it continues to affect behavior. Sometimes information is suppressed, that is, it is not being expressed or thought of, but it is possible for it to be recalled. The processes of availability and accessibility do not

perfectly parallel Freud's analysis of his observations but they could explain the phenomena he reported. Much of the information sought in psychoanalysis may not have been immediately accessible through free recall, however, it could be considered available, since through free associating, and interpretation, cueing, it was recalled.

It is the purpose of this report to investigate the appropriateness and usefulness of the availability-accessibility distinction in the study of the relation of stress and mnemonic processes. It is hoped that this and other distinctions will enable an analysis of the effects of stress on various cognitive components including acquisition, retention, and retrieval.

CHAPTER II

REVIEW OF THE LITERATURE

Stress and Learning

Much of the research on stress and learning has been influenced by the theory of C. L. Hull (1943) that noxious stimulation has drive properties. According to the fundamental formulation:

$$\text{Performance} = f(D \times H)$$

stress should facilitate performance. In 1964, Spence reviewed 25 investigations, of which 21 supported Hull's theory and Spence's own extension of it. All these studies involved differences between high and low anxious subjects, as defined by the Taylor Manifest Anxiety Scale, and eyelid conditioning. Along with all the attention that this theory has attracted has come a great deal of criticism. It appears that conditioning which does not involve a noxious unconditioned stimulus does not result in a difference between performance of high- and low-anxious subjects (Bindra, Peterson, and Strzelecki, 1955). In general, the prediction that anxiety facilitates performance proved too simple since in many situations, especially more complex tasks (Saltz, 1971), high-anxious subjects performed more poorly. To account for this, Spence suggested that anxiety would facilitate whichever habit was

dominant, be it the correct or incorrect response.

In addition, Spence and Spence (1966) suggested that drives produce discriminative stimuli (SD) and that these SD may evoke responses which are incompatible with the experimental tasks. A number of writers (e. g., Castaneda, 1956; Chiles, 1958) extended this theorizing to predict that stress would facilitate performance when the correct response was dominant and would be detrimental when an incorrect response was dominant. Thereafter, much of the research done in this area was specifically designed to test the above notions, but without consistent results as shall be shown. This research will lead us to a different conclusion.

Besch (1959) reports two paired-associates experiments which test Spence's hypothesis. In the first experiment, intra-pair associations were high, while between-pair associations were low. This arrangement presumably made the correct response dominant, and so it was predicted that shocked subjects would perform better than unshocked subjects. Instead, the performance of shocked subjects was significantly poorer. In the second experiment, some pairs were highly related and some were not. Again shocked subjects performed more poorly, but to a lesser degree in the case of highly related pairs. There is nothing especially noteworthy about this latter finding except, perhaps, the point that even stressed subjects profit from more relevant cues. There is the possibility that stress causes an output deficit as opposed to an acquisition or retention deficit, and that relevant cues

compensate for the inability to retrieve information that is retained. A similar distinction is made by Tulving and Pearlstone (1966) in terms of availability and accessibility, and differences in recognition and recall tasks reflect this distinction.

A study by Chiles (1958) bears upon this question. It is perhaps the only report that found an increment in verbal performance with shock. In terms of Spence's theory, it is important to point out that this improved performance occured both when the dominant response was correct and when it was incorrect. An important difference is found in Chile's task. Unlike most paired-associates studies in which the subject anticipates the response term after being exposed to the stimulus term, Chile's subjects were exposed to two alternative responses and were required to simply recognize the correct response. Superior performance effects were about equal for high- and low-associate responses.

Another study investigated both recall and recognition of meaningful words presented while the subjects were threatened by stress (Silverman, 1954). Several facts make this information difficult to evaluate relative to our interests here. First, 20 meaningful words were played through a muffled speaker at a sound-level intensity approximately as loud as "subdued conversational speech" while the subject was engaged in a stimulus discrimination task. These words were considered incidental stimuli and the subjects were told nothing about them and thus were at liberty to attend to them or ignore them.

Another fact which causes some difficulty, is the fact that all experimental groups performed better on recall than on recognition. Under these conditions, the non-threatened group performed better on both recall and recognition. But, while the non-threatened group recalled almost twice as many words as the threatened group, they recognized only about half again as many as the threatened group. From this information little can be concluded, and it still seems reasonable to ask what differences might exist between stressed and non-stressed subjects in terms of recall and recognition or some other tests of availability and accessability.

There seems to be less question about the effect of stress on recall. For meaningful and nonsense materials, shock or the threat of shock produces a decrement in recall performance (Besch, 1959; Deese, Lazarus, and Keenan, 1953; Lazarus and Longo, 1953; Lee, 1961; Silverman, 1954). Two studies (Lazarus, Deese, and Hamilton, 1954; Reece, 1954) report non-significant differences between shocked and non-shocked subjects. However, in both cases, the authors note that there was a low degree of learning by both groups, and conclude that the material must have been too difficult.

Attempts to manipulate psychological stress by telling subjects they have failed on a previous task provide somewhat sketchy information about the effects of this type of stress on learning on recall type tasks only. Three studies (Sarason, 1957; Sears, 1937; Taylor, 1958) report that failure instructions did result in decreased

performance in recall of nonsense materials. Three other studies (Lucas, 1952; Mandler and Sarason, 1952; Sarason, 1957) report no overall effect of failure, but do report an interaction effect between instructions and anxiety as defined by scores on personality tests. These last three reports point to just one of the difficulties involved in attempts to manipulate or evaluate psychological stressors, i.e., what stresses whom? Another difficulty, in this case, is convincing the subject that he has failed, and insuring that he does not detect the manipulation. In addition, information about failure may motivate some subjects to try harder, especially if they remain confident and/or can "undo" previous failure. It will be shown later that when "undoing" is least possible, failure tends to have an effect on recall.

The problem with these learning studies, as with many learning studies, is that the distinction between learning and performance is equivocal. That performance is impaired by stress is pretty well supported. Most of the studies have assumed that this impairment has been a function of learning. Spence, on the other hand, specifically states that differences in performance are due to an increase in drive (D), a motivational component, rather than habit (H), the learning component of performance.

The distinction between learning and memory is similarly unclear. None of the studies reported have, for example, compared the differences between groups stressed only during the acquisition stage and groups stressed only during performance. There are studies

that claim memory is impaired by stress and these shall be reviewed next.

Stress and Memory

Several studies purport to demonstrate the effects of stress on memory; yet most fail to distinguish between learning, performance, and memory. Again, there is inconsistency among the results with some showing stress decreases recall, some showing it increases recall, and then a few that report insignificant results.

A number of studies have examined the relationship between failure and a restricted type of recall--the relative recall of tasks that have been completed versus tasks that have not been completed. Theoretically, completed tasks would be considered successes while uncompleted tasks would be considered failures. Others (Eriksen, 1966; Glixman, 1949; Saltz, 1971) have reviewed these studies and concluded that failure does lead to a reduction in recall. For example, Glixman (1949) re-analyzed the data reported by Alpen (1946) and Rosenzweig (1943) and presented data of his own to support such a conclusion, but not without difficulty since Alper (1946) found a significant decrease in recall for completed materials, but not for incompleted materials. Glixman (1949) found just the opposite, i. e., a significant decrease in recall for incompleted tasks and nonsignificant decrease in recall for completed material. Rosenzweig (1943) found an insignificant increase in recall of completed materials, and an insignificant

poorer recall of noncompleted tasks. In other words, results were mixed. In a more recent review, Eriksen (1966) points out what one might have expected since a psychological stressor was employed, namely that individual differences can be related to personality variables.

A later study by Caron and Wallach (1957) did support Glixman's conclusion that total recall is reduced by failure manipulations. This study is especially interesting for its attempt to analytically differentiate between the effect of failure on learning and memory. Glixman (1949), Alper (1946), and Rosenzweig (1943) held that failure would lead to a "repressive" recall pattern. Caron and Wallach (1957) pointed out that even when failure was effective, it was not definitive proof of repression. An alternative explanation, they observed, was selective learning:

> The essential postulate of repression theory is that threatening events are not actually forgotten but persist in an unconscious state, continuously striving to regain consciousness. Morever, should the threatening character of repressed events be allayed (via psycho-therapy or other means), they should re-emerge into consciousness. The selective learning position, on the other hand, implies no such restoration for forgotten items: it assumes that decreased recall results entirely from a deficiency in original registration. The two interpretations thus offer different predictions for the recall of events whose threatening nature is allayed after learning--the repression view implying enhanced recall, the selective learning view implying no change in recall, for such items (p. 372).

To put the two views to the test, Caron and Wallach (1957) had subjects attempt to arrange 16 scrambled sentences into meaningful sentences. Half of the sentences were meaningless and therefore

considered unsolvable. Thirty-three subjects were told the experimenter was interested in eliminating tasks that required too much time. Eighty-four subjects were exposed to the stress condition. They were informed they were taking an intelligence test, which fellow students tended to do well on, and they were exposed to stooges that pretended to complete even the impossible tasks within the alloted time. Before testing, half of the stressed subjects were told that the entire situation had been a hoax--that half the tasks had been unsolvable, and that the apparent geniuses in the group had really been E's accomplices. It was theorized that this maneuver would eliminate the threatening character of any repressed information and allow a better recall performance if the repression theory were correct. If the selective learning theory were correct, then both stress groups should perform about equally well. The results supported this latter conclusion, i.e., both stress groups did equally poorly relative to the neutral condition subjects. This data suggests that reduced performance is not due to a mnemonic reaction. Such an important conclusion deserves further attention and/or demonstration, especially as other studies discussed below do not rule out the possibility of a mnemonic reaction.

A different approach is found in another group of studies. Basing their argument on the hypothesis of reverberating circuits, Kleinsmith and Kaplan (1963) predicted that arousal and recall interval would interact in their influence on paired-associate learning. In short, arousal would cause neural traces to continue to reverberate

for some time until eventually "consolidation" took place. Thus as time progressed, recall would improve for information learned during high arousal. To test this, eight words were selected which were considered capable of arousing subjects--kiss, rape, vomit, exam, dance, money, love, and swim. These words served as stimulus associates, while the digits 2-9 served as response associates in a paired-associates task. During exposure, the subject's GSR was monitored, and thus, for each subject, the E's selected the three highest and three lowest arousing stimuli. Then subjects were tested after various time delays up to one week later. The prediction was confirmed. High arousal learning showed a marked reminiscence effect, that is, poor immediate recall but high permanent memory, while low arousal learning showed a typical forgetting curve pattern.

In a second study (Kleinsmith and Kaplan, 1964), nonsense syllables of zero association value were selected as stimuli in order to obtain random arousal effects as defined by GSR response. Similar results were obtained and the authors claimed further support for the theory of reverberating neural circuits.

Weiner and Walker (1966) also manipulated arousal in their study of four incentive conditions and recall after five and fifteen seconds. There were four experimental conditions in a within-subjects design. Subjects could receive one cent for each correct response, or five cents. In a third condition subjects received nothing, while in a fourth condition subjects received a shock for each incorrect response.

After the five second interval, there were no differences in the recall performance under the different incentive conditions, but after 15 seconds, the five cent reward stimuli and the shock stimuli were recalled more often than the other stimuli. There was a noteworthy difference in these results. There was no reminescence effect for the high arousal incentives. These findings were explained in a manner similar to the account given by Kleinsmith and Kaplan (1964).

McLean (1969) also demonstrated this phenomenon in two experiments while he manipulated the arousal by the presentation of white noise at 85 db. This use of white noise, he figured, prevented rehearsal as well as arousal. There was a significant interaction between recall interval and arousal. In the first experiment, the subjects were not informed that the material being presented would be tested later. McLean termed this an incidental learning task. In the second experiment, subjects were informed of the nature of the task, so this was considered an intentional learning task.

Corteen (1969) reported similar results. The primary difference in his study was in his monitoring technique. Instead of GSR he used skin conductance.

It would be extremely hazardous to equate a state of arousal as defined by GSR or skin conductance with a state of stress. Only the Weiner and Walker (1966) study used one of the traditional operational stresses--threat of electric shock. And, under this condition, there was no reminiscence effect, i. e., there was no improvement in

performance as delay of recall increased, just a less rapid decrement in performance relative to other, "less arousing" incentive conditions. This improved performance under threat of shock is not atypical of other studies in which good performance served as an avoidance response (c.f. Saltz, 1971, p. 442). If the states of arousal discussed above were considered equivalent to stress, the results of the studies would stand in direct contrast with clinical experience and evidence from other studies including the majority of those reported above. There are two studies (Rosen, 1963; Uhlmann and Saltz, 1965) that investigated the effects of stress on retention over time and report a decrement in performance.

Rosen (1963) assumed that persons who had difficulty expressing hostility would find concentration camp stories more stressful than persons who could express hostility. Recall was tested immediately or after a 24 hour delay for neutral as well as stressful material. There were no differences in recall of neutral material as a function of ability to express hostility in either immediate or delayed recall, but there were differences for the stressful material with persons who had difficulty accepting hostile impulses showing a significant decrement in delayed recall.

A study by Uhlmann and Saltz (1965) also suggests that delayed recall is more susceptible to stress than is immediate recall. One qualification was that they predicted that field-dependent subjects (c.f., Witkins, Duk, Paterson, and Korp, 1962) would be susceptable to

stress. They selected field-dependent and field independent subjects by the results of a concealed figures test. The experiment consisted of presenting a newspaper account of a fire to subjects and obtaining immediate and delayed (3 hour) recall. Results indicated little drop in retention of non-stressful portions of the story showed significant drops in retention after delay for the field-dependent subjects.

There are alternative explanations for the results of the above two studies. It could be that stress affects recall over time only when observing specific personality types, or it could be that specific personality types were stressed by the types of material used, and that the decrements shown were primarily a function of stress per se. Or it is possible that certain personality types employ repression as a defense mechanism. The effects of stress on retention over time deserve further consideration.

Viewed as a whole, the studies reported in this section provide no clear cut picture of the effects of stress on mnemonic processes. Especially in conflict are the studies of Caron and Wallach (1957) and those of Rosen (1963) and Uhlmann and Saltz (1965). The former study appeared to rule out the possibility of a mnemonic response to stress while the latter reports seemed to demonstrate that very effect.

Inaccessible Memory

From documented records (Luria, 1968) and folklore (Erickson, 1962), there have been reports of amazing feats of memory. Much

interest has been shown in the possibility of an elaborate mnemonic structure that contains much more information about the past than everyday experience and typical recall tasks demonstrate. The studies reported below are primarily concerned with demonstrating more accurate or more complete mnemonic retrieval as a function of specific eliciting techniques. Available memory traces are of extreme interest in a discussion of the effects of stress on cognitive processes since there is the possibility that stress differentially affects availability and accessibility.

A controversial issue concerns reports of the purported phenomena known as "hypermnesia" (Neisser, 1966). Hypermnesia is taken as meaning that a permanent memory exists for all experience. Penfield and Roberts (1959) offer as evidence some observations made by Penfield during brain operations. Penfield regularly applies a gentle current to the exposed cortex of the patient and in some cases has elicited from the patients reports of extremely vivid memories, so vivid as to be taken as exact replications of the original experience. This information is presented as evidence of a permanent record of the stream consciousness. Some students of hypnosis (Erickson, 1962; Reiff and Scheerer, 1959) also argue for a fully preserved earlier state of mind. Reiff and Scheerer (1959) used age-regression, hypnotic techniques to demonstrate the phenomena they called "memoria," an experience that "...truly becomes a reliving."

Neisser (1966) presents some of the pointed arguments against

the assumptions made in theories of hypermnesia. It is not likely that anyone will demonstrate the retention of a continuous memory for all experience covering a lifetime, and confabulation is nearly impossible to guard against. However, he concludes: "If the 'permanent record of the stream of consciousness' is a fiction, there is no doubt that our memories can store a great deal of information for very long periods of time."

This phenomenon of inaccessible memory has been demonstrated and studied by several techniques and has been known by many names. There seems every reason to believe that the following studies have all been concerned with essentially the same problem.

Psychoanalysts have long believed that one way to retrieve repressed experiences is through the use of free associations. Haber and Erdelyi (1967) describe one of the better laboratory demonstrations of this technique and the reaction it evokes which has been variously known as "the Poetzl Phenomenon," "activitation," "the emergence effect," and the "recovery effect." In their study, a complex picture was shown briefly to subjects and recall for detail followed immediately. Experimental subjects were then instructed to free associate to the picture for 35 minutes while control subjects played darts for that interval. Afterwards, experimental subjects were able to recall more details than they had during immediate recall while controls were unable to improve their scores. In a latter paper, Erdely (1970) reported two experiments that suggested that free associating

"augmented response rates rather than sensitivity to the stimulus trace." The first experiment essentially replicated the earlier study by Haber and Erdelyi (1967) except for the fact that experimental and control subjects were tested with a forced-recall measure after the free-recall measure. On the free-recall measure experimental subjects did better than control subjects, but there were no significant differences on the forced-choice measure. In the second experiment, a recognition indicator with confidence ratings was employed, which allowed another measure of sensitivity and again there were no differences between fantasy and nonfantasy groups. Erdelyi concluded that fantasy augmented response rates and not sensitivity.

Like Neisser (1966), Shepard (1967) felt intuitively that typical laboratory experiments underestimated the limitation of human memory. He considered the hypothesis of hypermnesia "little more than an interesting conjecture," but he directed his experiments toward the demonstration of remarkable assimilation and retrieval rates under "normal conditions (i.e., without recourse to hypnosis, brain stimulation, drugs, etc.)." Judging by the reactions of others (c.f., Kintsch, 1966), he succeeded. He employed a forced-choice recognition technique in which an "old" item presented previously was paired with a "new" item not presented before, and the subject was instructed to choose the old item. In the first experiment, the subjects were given 540 single words to inspect, and tested on 60 word pairs. On the average, they correctly identified 88.4 percent of the old items. In the

second experiment, subjects were given 612 English sentences to inspect, which were followed by 68 test pairs. On the average, subjects correctly identified 89.0 percent of the items. Finally, 612 pictures were presented in the third experiment and followed by 68 test pairs. Correct recognition occured 96.7 percent of the time on the average. Shepard also tested picture recognition after delays of 2 hours, 3 days, 7 days, and 120 days. Percents correct on test pairs were 99.7, 92.0, 87.0, and 57.7 percent for the delays described above. Unfortunately, Shepard did not test recall also, although it is easy to assume that recall would not have resulted in the accuracy that recognition achieved. Typically, recognition is superior to recall (Kendler, 1968). However, the task can be manipulated so that recognition can be drastically reduced. Tulving and Osler (1967) describe a procedure that resulted in recognition being inferior to recall. Still, recognition can be one technique of tapping inaccessible memory.

Tulving and Pearlstone (1966) considered comparisons between recognition and recall "only partly relevant" for distinguishing between availability and accessibility. Their technique has been discussed above and is known as cued recall. The results of their study were discussed above.

In summary, there is evidence of an availability-accessibility distinction with respect to memory. Because of psychoanalytic theory, it has long been assumed that negative affect results in a decrease in accessibility but not necessarily in a decrease in availability. Yet,

none of the studies on the effects of stress on memory have specifically included this distinction.

Summary and Purpose

A summary of the literature review precedes the statement of purpose in this section. Primarily, the literature was reviewed in such a way as to suggest that additional research is necessary, and to suggest what directions that research might take. Specifically, the following points were made:

1. Several learning studies that demonstrated the detrimental effects of stress did not attempt to segregate performance and learning variables.

2. One study (Chiles, 1958) showed an increment in verbal performance with shock when a recognition task was used.

3. Data from Caron and Wallach (1957) suggests that reaction to stress involves selective learning, not mnemonic reaction.

4. Recall of material learned during stress has been shown to decay less rapidly in one study (Weiner and Walker, 1966), and more rapidly in two studies (Rosen, 1963; Uhlmann and Saltz, 1965).

5. A mnemonic dimension that parallels the psychoanalytic variables of repression and various degrees of consciousness is the distinction between availability and accessibility.

These points suggest resolution by the following procedure which attempts to separate the various effects of stress on acquisition,

retention, and retrieval, as well as differences in the mnemonic variables of availability, accessibility, and delay of recall. Some subjects could be stressed during exposure to verbal materials to access the effects of stress on acquisition. Other subjects would be stressed only during recall to test the effects of stress on retrieval. Free-recall and cued-recall differences would provide information on retrieval, retention, and availability. Finally, mnemonic reaction is further investigated by testing differences immediately and after some delay.

Specifically, the following is being tested:

1. The selective learning hypothesis, that predicts subjects stressed during acquisition will not perform as well as subjects stressed during recall immediately and after a delay.

2. The repression hypothesis that suggests that subjects stressed during recall will perform poorly relative to subjects stressed during acquisition, or not stressed at all.

3. The repression hypothesis that suggests that stress will affect free-recall more than cued-recall, in that cued-recall, like free-association, is a technique for eliciting inaccessible material.

4. And finally, the possibility of a mnemonic reaction that is dependent on the passage of time.

CHAPTER III

METHOD

Subjects

The S's consisted of 96 undergraduate students, who were enrolled in psychology courses for undergraduate credit, at Oklahoma State University. All S's volunteered for inclusion in the study, and were given extra credit as incentive. All S's were naive with respect to the experimental task. S's were randomly assigned to the various treatment combinations with insurance that the sexes were evenly distributed across treatments.

Apparatus and Materials

The stressor apparatus was simply a foam ice bucket filled with water and ice and maintained at a temperature of 32^{o}F plus or minus 2 degrees. This bucket was positioned to the left of the subject on a platform so that the hand of the subject could be immersed without the subject altering a normal sitting position.

The S's sat in a firmly padded chair in front of a desk. On top of the desk was a memory drum with three shades, each covering one third of the memory drum window. To the right of the desk sat the

Experimenter (E). From this position, E controlled the memory drum and recorded S's responses.

Attached to the rotating memory drum were six lists of 20 words. Each list was followed by a three-digit number. Lists one and two were practice lists and appeared in the middle portion of the window. Test lists three and four appeared in the middle portion of the window. Test lists five and six were identical to lists four and three respectively, and were presented on the right hand side of the window. This latter arrangement simplified the balancing of order of list presentation.

Treatments

S's were randomly assigned to one of six treatment conditions composed of 16 S's each. These treatment conditions involved combinations of one of three stress conditions and one of two recall conditions. The three stress conditions were: hand in ice water during exposure to the test lists (A); hand in ice water during recall of words (R), and no exposure to ice water (N) as a control condition. The two recall conditions were free recall (F) and cued recall (C). The test lists and the cues for each word are presented in Appendix A. In addition, each subject recalled one test list immediately after counting backwards from the three digit number at the end of one of the lists by threes for five seconds, and each subject recalled a second list after a three minute delay which included counting backwards by threes for

five seconds and repeating the alphabet in reverse for the remaining time. These last two conditions were coded "Immediate" (I) and "Delay" (D).

The order of list presentation and the order of I and D were counterbalanced across all six experimental treatments.

Procedure

Each subject was asked to sit in the chair in front of the memory drum. E introduced himself, thanked the S for coming in, and explained the experiment as follows:

> I want to explain the experiment to you. We are testing people's reactions to various conditions. Right now we need people who are willing to tolerate a mild degree of discomfort. You will be asked to put your hand in cold water for a short period of time. Although this experience is uncomfortable it is far from being dangerous. If you are willing, you will receive extra credit from your psychology instructor. Are you willing?

All S's volunteered to continue with the experiment, and all were able to complete the task. Next, the S's were told:

> Perhaps the most important thing that we ask of you is that you promise not to discuss this project with anyone until the results of the study are discussed in your class. Can you promise this? Have you heard anything about the nature of this study?

All S's promised not to discuss the project with others. All S's claimed they had no knowledge about the experiment from others. Controls (N's) were then told: "Even though you volunteered, you will not be asked to put your hand in the ice water. We only wanted to

insure your willingness."

All subjects were then told:

> The experiment is quite simple. In front of you is a memory drum. Words will appear in the window of the memory drum which we ask you to read out loud. At the end of a list of words you will be asked to recall as many of the words as you can remember. Any questions? At the end of the list is a number. Read the number out loud and begin to count backwards by threes. For example, if the number were 119, you should count 119, 116, 113, 110, and so forth until you are told to stop. Any questions?

All questions related to procedure were answered, while all questions related to purpose were answered with a reminder that the study would be explained in a regular class session. After two practice lists, subjects in groups A and R were told:

> We will continue to proceed as we have been except at various times I will ask you to put your hand in the water you see at your left. I want you to submerge your hand up to your wrist, when I tell you to. I will also tell you when to take it out. Are you ready?

Special instructions were given to S's in the cued (C) condition: "I am going to give you hints for each of the words in the list." And in the delayed (D) condition the subjects were asked to stop after counting backwards for five seconds, and then told to say the alphabet backwards and repeat this if necessary until the three minute delay period was ended.

Research Design and Summary

The design chosen for this study was a three-factor experiment

with repeated measures. There are repeated measures only on the immediate-delay recall condition. With only two repeated measures, the homogeneity of covariance assumption is not tested (Winer, 1962).

The three factors were stress condition, recall condition, and delay condition. Subjects were exposed to the ice water stressor either during acquisition (A), during recall (R), or not at all (N). During testing, subjects recalled freely (F) or with cues (C). All subjects were tested twice; once immediately after exposure to the lists and counting backwards for five seconds (I), and once after a three minute delay (D). The significance level chosen for this study was .01.

CHAPTER IV

RESULTS

Individual subject's scores are recorded in Appendix B. These scores were subjected to an analysis of variance, multiple factor design, with repeated measures (Winer, 1962). The necessary assumptions for this type of analysis were tested by subdividing the error terms and testing for homogeneity by means of F max tests (Winer, 1962). The error between F max statistic was not significant at the .01 level (F max = 4.11, d.f. = 6115). And, the error within F max statistic was not significant at the .01 level (F max = 1.837, d.f. 6/15). The assumptions were supported. The summary of the analysis of variance is reported in Table I.

TABLE I

SUMMARY OF ANALYSIS OF VARIANCE OF CORRECT RECALL BY STRESS GROUP, RECALL CONDITION, AND DELAY OF RECALL

Source	d.f.	SS	MS	F
Between S's	95	3684.620		
A (Stress)	2	241.350	120.568	18.174**
B (Recall)	1	2829.005	2829.005	426.440**
AB	2	17.448	8.724	1.315
Error between	90	597.032	6.634	
Within S's	96	748.500		
C (Delay)	1	399.630	399.630	106.256**
AC	2	.199	.099	.027
BC	1	.005	.005	.001
ABC	2	10.135	5.068	1.347
Error within	90	338.531	3.761	

**p < .01

The main effect for the stress conditions was significant (F = 18.174, d.f. = 2/90, p < .01), indicating that the ice water stressor did influence recall performance. To determine the various effects of the three stress treatments, differences between treatment totals were computed by using Newman-Keuls multiple range test (Winer, 1962). The summary of the Newman-Keuls multiple range test of the three stress treatments is presented in Table II, and shows that each treatment differed significantly from each other treatment at the 0.1 level. The order of performance from best to worst was the No Stress Group

(N), Stress during Recall (R), and Stress during Acquisition (A).

TABLE II

NEWMAN-KEULS MULTIPLE RANGE TEST OF THE PERFORMANCE TOTALS OF THE THREE STRESS GROUPS

Stress Condition	A	R	N
Recall Totals	1	2	3
	590	650	763
1 590		60**	173**
2 650			113**
3 763			
Truncated Range	2	3	
99 (r, 90)	3.76	4.28	
99 (r, 90) $\sqrt{nMS_{error}}$	54.78	62.36	

**p < .01

The main effect for the recall condition, cued versus free, was also significant (F = 426.440, d.f. = 1/90, p < .01). The means for all cued and freely recalled conditions were 14.271 and 6.594 respectively.

The main effect for the delay condition was significant (F = 106.256, d.f. = 1/90, p < .01) with the means for the five second delay

(I) and the three minute delay (D) respectively, 11.875 and 8.989 correctly recalled words.

None of the interactions effects was significant which indicated that all of the main effects were independent of one another. Table III presents treatment means and standard deviations for each of the twelve treatment combinations. Figure 1 represents a summary of the data.

TABLE III

MEANS AND STANDARD DEVIATIONS FOR ALL TREATMENT COMBINATIONS

STRESS						
RECALL						
IMMEDIATE						
	MEAN	6.375	14.875	7.750	15.437	10.000	16.812
	SD	1.200	4.250	4.070	5.460	3.070	2.830
DELAY						
	MEAN	4.125	11.500	4.312	13.125	7.000	13.875
	SD	3.720	5.070	3.300	10.250	7.730	9.720

Two considerations led to a different analysis of the data. First, because there was no significant stress X recall interaction it became apparent that the different stress conditions resulted in disproportionate differences in the two recall conditions. Cueing resulted in a

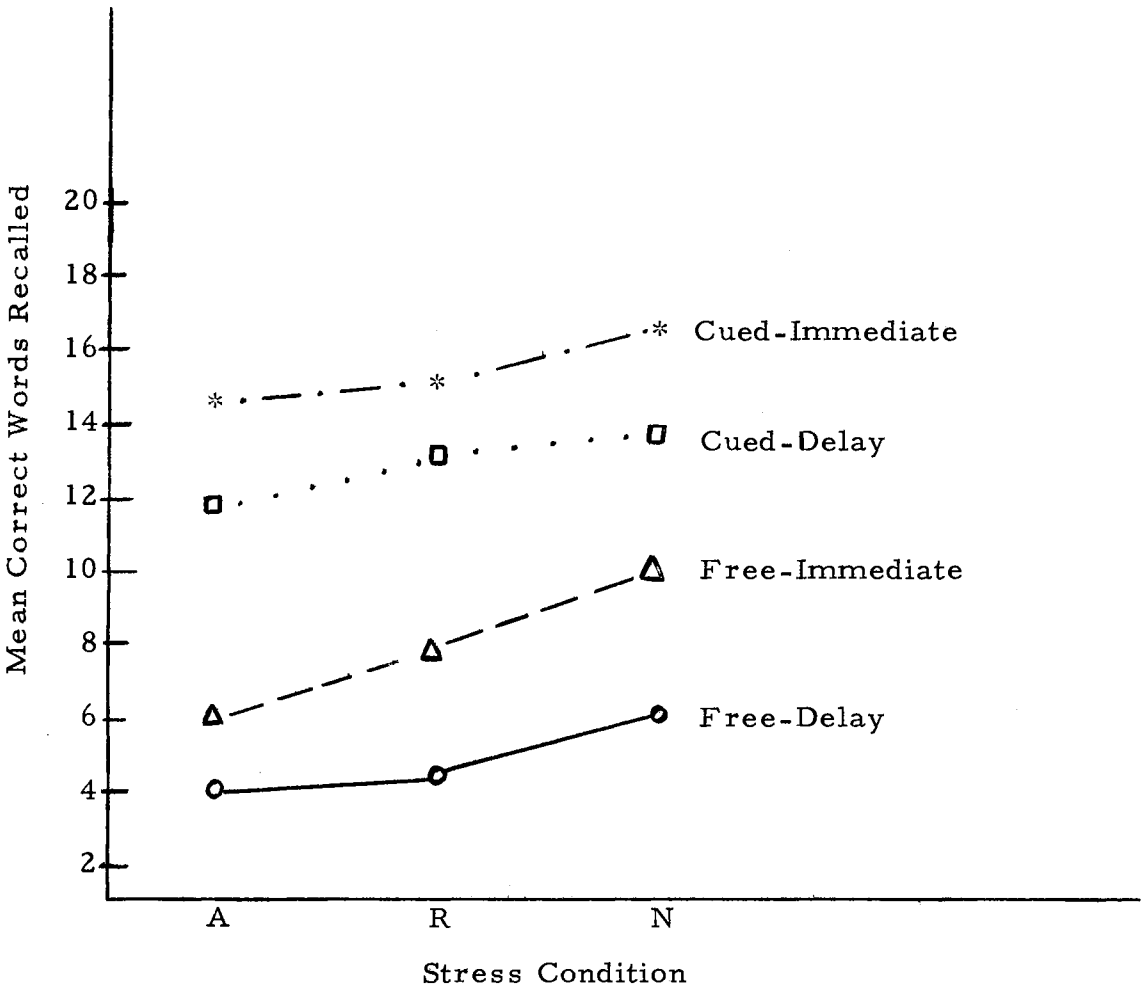

Figure 1. Mean correct recall as a function of stress, recall, and delay conditions

rather constant increase in recall across all stress conditions. This increase was 7.677 words on the average and varied plus or minus 0.8 words for the three stress conditions when collapsing on delay conditions. The second consideration was for the fact that unit changes, expressed as differences in numbers of words recalled for the two recall conditions, might not reflect differences in the difficulty of the two tasks. It could be argued that since cueing results in higher scores, the word unit does not represent as great a difference as in free recall.

To reflect these observations, the second analysis was based on each score expressed as a percentage of the average of all scores for the same recall and delay combination. The average numbers of words recalled in the free-immediate, free-delay, cued-immediate, and cued-delayed conditions were calculated. Each individual's score was then divided by the appropriate average and multiplied by 100. An analysis of variance identical to the one already reported was performed, with the only difference being that scores were expressed as percentages as described above. A summary of this analysis is presented in Table IV. The homogeneity of each error term was tested by the F max statistic (Winer, 1962). The assumptions were met for the Error Between term (F max = 6.062, d.f. = 6/15), but not for the Error Within term (F max = 7.162, d.f. -6/15, $p < .01$). However, only effects tested with the Error Between term were significant. The stress effect was significant ($F = 22.034$, d.f. = 2/90, $p < .01$), and the

stress X recall term was significant ($F = 7.193$, d.f. 2/90, $p < .01$). As can be seen in Figure 2, these results are due to smaller percentage differences from the appropriate means in the case of cueing, and larger differences in the case of free recall.

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE OF CORRECT RECALL WHEN SCORES ARE EXPRESSED AS PERCENTAGES OF RECALL AND DELAY TREATMENT MEANS

Source	d.f.	SS	MS	F
Between S's	95	128637.917		
A (Stress)	2	37421.448	18710.724	22.034**
B (Recall)	1	22.687	22.687	.026
A x B	2	12568.032	6284.016	7.193**
Error Between	90	78625.750	873.619	
Within S's	96	63666.000		
C (Delay)	1	2.083	2.083	.003
A x C	2	1058.886	529.443	.783
B x C	1	.022	.022	.000
A x B x C	2	1741.759	870.379	1.287
Error Within	90	60860.250	676.225	

** $p < .01$

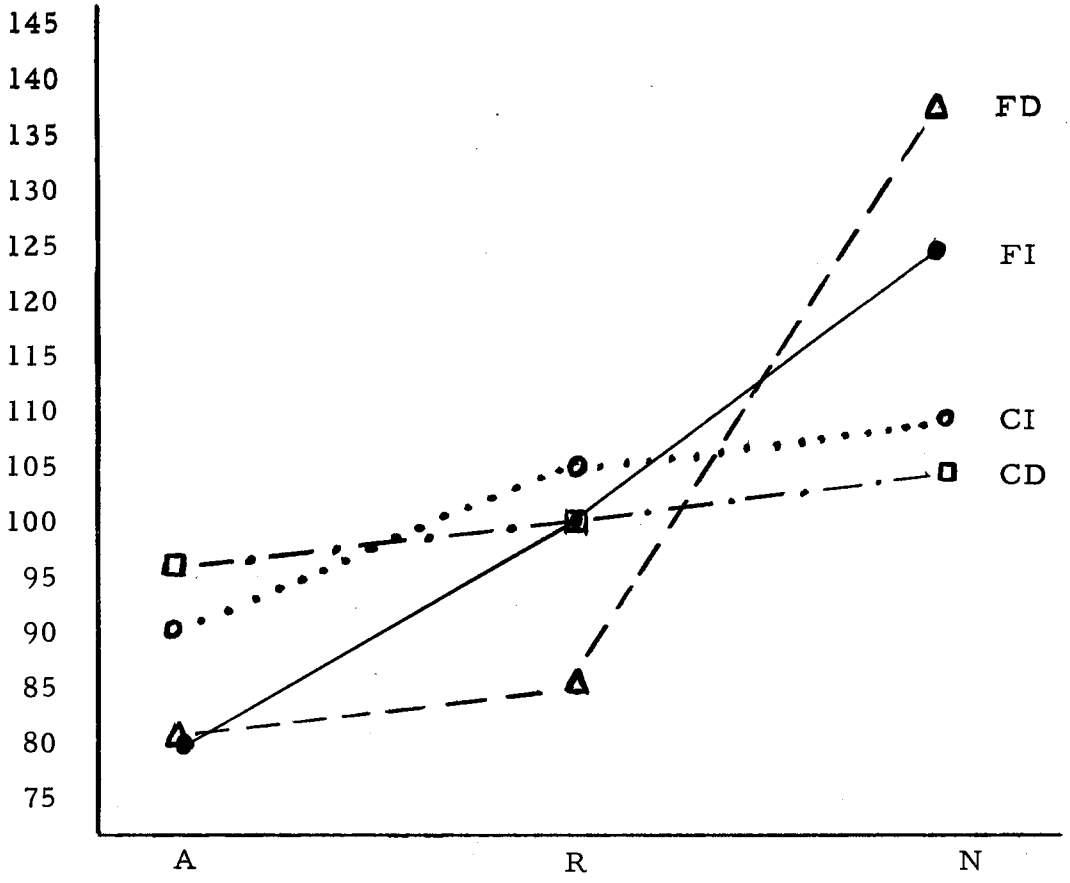

Figure 2. Mean correct recall as a function of stress, recall, and delay conditions when scores are calculated as percentage of recall and delay treatment means.

CHAPTER V

DISCUSSION

Four specific hypotheses were tested by the method described in Chapter Three and the results bearing upon these hypotheses were presented in Chapter Four.

The selective learning hypothesis predicted that subjects stressed while being exposed to the lists of words would not perform as well as subjects stressed during recall. This prediction was supported by the results and was independent of the recall and delay conditions. These results suggest that one of the reasons for the psychoanalytic phenomena of repression is that some of the information is not learned.

The repression hypothesis predicted that subjects stressed during recall would perform poorly relative to subjects stressed during acquisition, and of course, this prediction was not supported by the results. However, the repression hypothesis also suggests that subjects stressed during recall would perform poorly relative to the control subjects. This position was supported by the results.

These two approaches to the phenomena of repression are not totally mutually exclusive but are perhaps appropriate for different situations. Combined with the results of the 1957 study of Caron and

Wallach, this study suggests that acquisition is inferior during a state of stress and that removal of the stressor does not result in retrieval equivalent to non-stressed subject's performance. On the other hand, this study does support the contention that stress during retrieval does suppress performance. There is an interesting question which can be asked. Presumably, the subjects who were stressed during recall had acquired as much information as the control subjects. What happened to this information? Was this information lost or was retrieval interferred with?

The cued and free recall conditions were included in this study to test a repression-type hypothesis that predicted smaller differences among the stress groups with the cueing technique for eliciting inaccessible material. However, there was no significant stress X recall effect, and so this hypothesis was unsupported. There can be a question raised about the efficacy of this technique for eliciting all retained material. The retrieval rates for cueing are less than those reported by Shepard (1967) for recognition of similar material, viz., single words, and Shepard's subjects were exposed to 540 words, and tested with 60, which can be viewed as a more difficult task when compared with the one used in this study.

The immediate and delayed recall conditions were included to test the possibility of a mnemonic reaction that is dependent on the passage of time. The delay main effect was significant, however, delay did not interact in any combination with the other main effects.

Thus, this study suggests a middle ground between the Weiner and Walker report (1966) which showed loss of material learned during stress occuring less rapidly, and the results of Rosen (1963) and Uhlmann and Saltz (1965) which recorded more rapid losses. Among other differences, the delay period varied considerably among all of these studies. For the Weiner and Walker study (1966) it was only 15 seconds. In this newest experiment, reported in this paper, it was three minutes. Rosen (1963) and Uhlmann and Saltz (1965) chose 24 hours and 3 hours respectively. These figures suggest that the appearance of a stress X delay interaction might require the longer delay periods measured in terms of hours, e.g. 3 or 24, rather than seconds or minutes. This remains speculation until further demonstration.

The lack of a significant or even apparent stress condition X recall condition interaction is one of the more interesting and puzzling aspects of this report. If differences among the stress conditions had been reduced in the cued recall condition, then differences among stress groups would have been explained primarily as differences in the ability to retrieve, or differences in accessibility. On the other hand, if cueing had resulted in increased differences in the same directions as free recall, it would appear that the different stress conditions caused proportionate increases in free and cued recall conditions. For example, the free recall group, which was stressed during acquisition, recalled 5.25 words on the average ignoring delay conditions. The no stress, free recall group recalled 8.5 words on the

average, ignoring delay conditions. This represents a 62 percent increase. Now in the cueing condition, the no stress group recalled only 16.36 percent more words than the stress-during-acquisition group. Because there were no significant interactions, we can say cueing resulted in a rather constant increase in recall across all stress conditions. This increase was 7.677 words on the average and varied plus or minus 0.8 words for the three stress conditions. If we assume cueing evokes responses which are both available and accessible, and free recall scores reflect only accessible material, then we find disproportionate amounts of material were accessible across the three stress conditions. In our case, for the group stressed during acquisition, 38.4 percent of the available memory was accessible. For the group stressed during recall, it was 42.2 percent and for the no stress group it was 55.4 percent. So while differences in amount of information available but inaccessible were constant, differences in proportions of information available but inaccessible did vary. This rather complex discussion has been offered in the hope that it would further delimit and delineate the nature of the mnemonic reactions associated with stress. While the phenomena of varying proportions of accessible materials is consonant with a repression-type theory, these findings suggest that more precise discussions would be appropriate. It can be pointed out that an important variable to investigate with regard to disproportionate accessibility would be different amounts of information, e.g., different lengths of words. It is possible that a

stress condition X recall condition X amount of material condition interaction would be significant. It might be found that different lengths of lists cause varying increases or decreases in disproportionate accessibility. In nature, one finds differences in the amount of information depending upon the passage of time and the complexity of the situation.

From an overall view, this study demonstrates the complexity of mnemonic reactions to stress. This is not surprising when one considers the complexity of human existence. It is through the most analytic of studies that the mysteries are likely to be solved. It is our contention that the learning nature of man is better known than the cognitive nature of man, and that exploration of the latter may prove to be as rewarding as the exploration of the former.

CHAPTER VI

SUMMARY

This study investigated the effects of a cold water stressor on the acquisition and retention of meaningful words with two types of recall tasks after two different periods of delay. A selective learning theory predicted subjects exposed to the stressor during exposure to the words would not recall as well as subjects exposed to the stressor during recall. A repression theory predicted stress during recall would reduce performance relative to no stress and that cueing would reduce differences among stress and control groups relative to free recall. Recall followed delays of five seconds and three minutes to access possible difference in forgetting rates.

The no-stress group performed significantly better than both stress groups ($p < .01$). The stress-during-recall group performed better than the stress-during-acquisition group ($p < .01$). Immediate recall and cued recall enhanced performance ($p < .01$). There were no significant interactions among the main effects of stress condition, recall condition, and delay condition. It was concluded that the hypothesis of selective learning and repression applied to different situations. Differences in proportions of available memory that were accessible, and implications for future research were also discussed.

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APPENDIX A

WORD LISTS AND CUES USED IN STUDY

Practice Lists	Test Lists	Cues for Test Lists
PICTURE	MILE	a measure of distance
ATLANTIC	HYDROGEN	a basic element
SUGAR	MILK	something to drink
MARY	FOOTBALL	a sport
BISCUIT	PEACH	a fruit
PRISON	RAPE	a crime
SAIL	THREE	a number
PSYCHOLOGY	OCEAN	a body of water
FRIEND	TROUT	a fish
BOOK	SHIRT	an article of clothing
WINDOW	SCREWDRIVER	a tool
TELEPHONE	NEWSPAPER	something to read
HEATER	BROTHER	a relative
DOLLAR	CHICAGO	a city
HAIR	GUNSMOKE	a television show
WATCH	TERMITE	an insect
HOUSE	VANILLA	a flavor of ice cream
POSTER	BISHOP	an official in the Catholic Church
HELMUT	RADIO	something to listen to
TREE	OREGON	a state
TELESCOPE	THANKSGIVING	a holiday
BUILDING	TABLE	a piece of furniture
PAPER	REMBRANDT	a famous painter
FAMOUS	CHEVROLET	an automobile
HALL	SCULPTURE	an art form
GLUE	HISTORY	a subject studied in school
MOON	YELLOW	a color
SIGN	BEATLES	a singing group
FIRE	NECKLACE	a piece of jewelry
DESK	SPARROW	a bird
HOSPITAL	EISENHOWER	a president
SHIP	VENUS	a planet
HUMAN	TIRE	a part of a car
GLOVE	TIGER	a four-legged animal
HORIZON	RUSSIA	a foreign country
INSTANT	FOXTROT	a dance
THEORY	AIRPLANE	a form of transportation
CROWD	JOHN	a man's first name
FLAG	POTATOE	a vegetable
HEALTH	TORNADO	a weather condition

APPENDIX B

INDIVIDUAL SUBJECT'S SCORES

Stress During Acquisition (A)				Stress During Recall (R)				No Stress Controls (N)			
Free		**Cued**		**Free**		**Cued**		**Free**		**Cued**	
I	D	I	D	I	D	I	D	I	D	I	D
8	6	15	11	5	3	16	16	10	12	20	14
5	6	14	10	8	3	17	9	12	6	16	17
5	3	17	16	8	5	12	8	7	3	17	9
4	6	14	10	8	6	13	12	12	11	17	18
3	0	15	8	7	2	16	13	12	5	18	17
6	6	14	11	9	3	13	10	9	6	15	15
7	4	17	14	7	9	15	11	8	11	16	15
7	4	17	14	7	9	14	11	8	11	16	15
7	2	11	12	11	3	14	14	10	9	17	15
6	3	12	12	7	5	19	14	11	9	15	14
6	5	15	9	8	5	15	14	7	4	17	9
6	7	14	11	7	5	16	20	8	4	14	7
10	5	16	13	11	4	19	17	11	8	15	13
8	2	20	15	7	5	12	12	10	8	18	16
8	3	14	13	11	3	18	17	11	5	19	14
7	3	15	10	4	6	18	12	10	5	16	13
6	5	15	9	6	2	14	11	12	6	19	16

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