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Time of arousal, degree of arousal and immediate and delayed recall of connected, meaningful material.

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TIME OF AROUSAL, DEGREE OF AROUSAL AND IMMEDIATE AND DELAYED RECALL OF CONNECTED, MEANINGFUL MATERIAL

by

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PREFACE

To paraphrase Bachrach (1963), whose delightful little book, Psychological Research, introduced me to the excitement of experimental psychology:

> It is customary to wait until the middle of a bullfight to dedicate the bull to someone in the audience. In that way it is known whether the bull is brave enough to be dedicated. Unfortunately, this is not possible with a dissertation; therefore, I am taking the "book" by the horns and dedicating it to prized mentors, colleagues and friends whose assistance contributed to the termination of the fight:

A. Arthur Smith

Robert C. Fehr Byron P. Rourke Raymond M. Daly

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and

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ABSTRACT

Four groups of seven undergraduates were presented with Bartlett's (1932) "The War of the Ghosts" in an attempt to assess the effects of degree of arousal as well as time of arousal on immediate (7 minutes) and delayed (24 hours) recall. Arousal was produced experimentally through the administration of a modified version of the Rapid Discrimination Test (RDT) originally developed by Belanger (1957). The groups were differentiated on the basis of whether the RDT was presented immediately before the story (Pre-Story), immediately after, (Post-Story), immediately before recall (Pre-Recall), or not at all (Control). Heart rate (HR) and a multiplicative measure (BR x DB) of breathing rate and depth of breathing were the physiological indicants of arousal employed. Recall was measured by the written recall method, with total number of content words (CW) as the scoring criterion. McCarter's (1961) Recollection Rating Scale (RRS) provided phenomenological data.

Analysis of the CW scores showed some statistically significant evidence that time of arousal affects immediate and delayed recall when arousal is mediated by the administration of RDT. The RDT did not, however, produce a statistically significant increase in arousal as reflected in absolute change in HR or BR x DB. When treatment groups were collapsed and within subject analysis of variance carried out, recall was significantly better ($p = 0.05$) for the high arousal group.

Phenomenological results indicated that the RDT produced puzzlement, but not increased arousal, as far as recollected feelings were

concerned. An interaction between accepting-rejecting feelings and recall interval was established ($p = 0.05$).

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CHAPTER I

INTRODUCTION

The study of memory includes the investigation of all those variables which are determinants of retentive behavior. Such variables traditionally have been those that generally are classified as associative variables - degree of original learning, frequency of stimulus presentation, meaningfulness of material, similarity of interpolated activity and original learning, degree of learning of interpolated material and so on. Weiner (1966) points out, however, that there are a number of pertinent questions which address themselves to the relation between "nonassociative" factors and retention. Further he states that

> It seems intuitively reasonable to submit that variations in the motivational variables existing at any of the stages in the memory process will affect subsequent recall (1966, p. 25).

Not only on intuitive grounds is such a submission reasonable; theoretically, as well as empirically, there are sound bases for Weiner's proposal. It is within the broad confines of this proposal that the present investigation can be placed.

According to Atkinson (1964) any contemporary determinant of behavior can be considered a motivational construct. This includes temporary and relatively stable states of the organism as well as characteristics of environmental objects or events. Subsumed under temporary and relatively stable states is arousal level. It was with

this variable, arousal, that the present study was primarily concerned, but not in a singular way. Rather it was an investigation which attempted to assess the effects of degree of arousal as well as those of time of arousal on immediate (7 minutes) and delayed (24 hours) recall of connected, meaningful material. Four groups of undergraduates were asked to read Bartlett's "The War of the Ghosts" and written reproductions of the story were made at 7-minute and 24-hour intervals. Arousal was produced experimentally through the administration of a modified version of Belanger's (1957) Rapid Discrimination Test (RDT). The groups were differentiated on the basis of whether the RDT was presented immediately before the story (Pre-Story), immediately after (Post-Story), immediately before recall (Pre-Recall) or not at all (Control). Heart rate (HR) and a multiplicative measure combining breathing rate and depth of breathing (BRxDB) were the physiological indicants of arousal employed. Recalls were scored for content words used in the original version of the story. McCarter's (1961) Recollection Rating Scale (RRS) provided phenomenological data.

There are several theoretical and experimental issues which provide the basic underpinnings of the present investigation. The presentation of these issues will be partitioned as follows: (1) theories of memory (with special emphasis on consolidation theory); (2) the findings of research stimulated by consolidation theory; (3) Malmo's (1959) activation hypothesis; (4) the findings of experiments relating muscular tension to recall; (5) the rationale for the use of RDT and "The War of the Ghosts"; (6) rationale for the use of two indicants of arousal; (7) rationale for the use of the Recollection Rating Scale (RRS).

Theories of Memory

Three major theories of memory have been proposed to account for the fact that man forgets: trace theory, interference theory and consolidation theory. In addition there is that which Osgood (1953, p. 554) terms the "repression sequence": "Although it does not pretend to be a general theory of forgetting, mention should be made of Freud's concept of repression and the motivated forgetting to which it is assumed to lead. Such forgetting is certainly a valid observation in the clinic and probably would be verified in the laboratory were adequate conditions designed to reveal it." Rapaport's (1942) Emotions and Memory provides the interested researcher with an extensive survey of experiments in whose unfolding will appear "a hierarchy of emotional factors and their influences on memory" as well as a hierarchy of experimental methodological difficulties.

Trace Theory

The basic assumption of trace decay theory is that memory for a certain event decays over the retention interval and that forgetting is a result of a weakened trace at the retention test. Gomulicki (1953) presents the development and present status of trace theory for the interested reader.

Trace decay theory is intuitively appealing to both the student of human memory and the layman with his conception of "impressions that fade with time". As Adams (1967, p. 23) points out, however, "intuitive attractiveness is insufficient for scientific theory". He further states that, "Trace decay may be the reason for forgetting, but activity in the retention interval must be proved as truly neutral and not an agent that

works to reduce the strength of the trace by interference with it". Ideally, an empty time interval is needed; realistically events, including memories of earlier events, occur in time. Thus any test of trace decay is confounded. Despite this major difficulty, trace decay theory has had its modern supporters. Among them are Broadbent (1958), Brown (1958), Conrad and Hille (1958) and Tolman (1949), but it has not attracted much attention since McGeoch's (1932) major attack on Thorndike's (1913) law of disuse which is another label for the trace decay theory.

The trace decay theory should be distinguished from the trace transformation view that was held by gestalt psychologists. Koffka (1953, p. 523) admitted the possibility of spontaneous decay of the memory trace, but proposed that a change in the configuration of the trace, not a weakening, was more probable. Gestalt psychologists were primarily interested in stimulus recognition, however, rather than in recall. It was Bartlett (1932) who emphasized the effects of transformation on recall. Bartlett had subjects read a North American folk tale twice to themselves. Fifteen minutes later a written reproduction was obtained; subsequent reproductions by the same individuals were obtained over a wide range of intervals. From a careful inspection of these serial reproductions, Bartlett synthesized certain general tendencies, among which were the following: (1) The general form of a subject's first reproduction is preserved throughout his own series; (2) There is a strong tendency to rationalize unconnected or disturbing elements; (3) Certain dominant elements may serve as focal points of organization, about which reasonable details are embellished; (4) Various

inventions, in tune with the subject's frame of reference, are worked into the reproduction. According to Bartlett, what is remembered is an emotionally oriented, meaningful core, which he termed "schema", about which is reconstructed a story made up of half-recalled and half-invented detail. Bartlett contended that the entire personality of the individual, his emotions, his attitudes, his cultural frame of reference, contributed to what he 'remembered'.

Interference Theory

In McGeoch's (1932) classic criticism of Thorndike's law of disuse, he wrote that, "Even were disuse and forgetting perfectly correlated, it would be fruitless to refer the forgetting to the disuse as such. Such reference is equivalent to the statement that the passage of time, in and of itself, produces loss, for disuse, literally interpreted, means only passivity during time . . . . In time all events occur, but to use time as an explanation would be to explain in terms so perfectly general as to be meaningless" (McGeoch, 1932, p. 359). As an alternative and more compelling explanation of forgetting, McGeoch (1942) proposed the competition-of-response formulation in which it is assumed that two response systems acquired in succession both remain available to the individual at the time of recall. If two responses are attached to similar or identical stimuli, competition occurs and the stronger response is given; responses of equal strength may inhibit or block each other. The competing responses learned before acquisition of new responses (proactive inhibition) or during the retention interval (retroactive inhibition) thus produce the performance decrement usually termed forgetting. The interference will be the result of either proactive or

retroactive inhibition depending on which of the two sets of responses is stronger.

Long term memory seems to be more susceptible to the effects of response competition than is short term memory (Keppel, 1968). Individual differences in susceptibility to interference also suggests that there are risks in making generalizations about the effects of interference. Jensen (1964), for example, found that individual differences in resistance to interference were related to memory span. These provisos notwithstanding, the evidence that interference is a fertile explanation of forgetting is very great. The interested reader is referred to reviews by Postman (1961) and Keppel (1968).

Consolidation Theory

Unlike either trace decay or interference theories which offer explanations of forgetting, perseverative consolidation theory attempts to explain the development of memory. It was Muller and Pilzecker (1900) who first proposed a pseudoneurological theory to cover many of the phenomena of remembering. In essence their theory stated that the neural correlates of learning persist through time after active practice has ceased and that this perseveration serves to strengthen or consolidate the associations formed.

This type of theory was later sponsored by Woodworth (1938) under the name, consolidation. It was Hebb's (1955) formulation of the conceptual nervous system, however, with its discussion of reverberating neural circuits which provided Walker (1958) with a mechanism to explain the effect of arousal on consolidation. Walker (1958, p. 130) first formulated his theory of action decrement as follows:

> Any psychological action is followed by an action decrement - a lowered capacity for rearousal of the same event. The action decrement is a direct manifestation of the process of perseverative consolidation which is necessary for retention and subsequent performance. The action decrement persists for a limited time and then dissipates. Under many circumstances the dissipation of the action decrement is followed by an action increment which is learning or habit strength.

Following this initial formulation, Walker took a further step involving the effects of different levels of motivation. He assumed, with Hebb (1955), that differences in motivational level correspond in some way to differences in nonspecific output from the reticular system and that "one would expect an increase in the level of nonspecific input from an increase in motivational level and thus an increase in the intensity of the original action or any subsequent cycle of it. This would produce a quicker recovery in absolute time, a steeper curve of recovery, and a greater potential increment" (p. 131). Furthermore, Walker had argued that "when one tracks the course of the action decrement experimentally one also, in fact, tracks the course of the perseverative consolidation which is frequently assumed to follow a period of training and is assumed to be necessary for subsequent performance" (p. 129). Thus, Walker's theory interrelates perseverative consolidation, action decrement and arousal. The relevant propositions of the theory are summarized by Walker and Tarte (1963, p. 113) as follows:

> (1) The occurrence of any psychological event, such as an effort to learn an item of a paired-associate list, sets up an active, perseverative trace process which persists for a considerable period of time.
>
> (2) The perseverative process has two important dynamic characteristics:

(a) permanent memory is laid down during this active phase in a gradual fashion;

(b) during the active period, there is a degree of temporary inhibition of recall, i.e., action decrement (this negative bias against repetition serves to protect the consolidating trace against disruption).

(3) High arousal during the associative phase will result in a more intensely active trace process. The more intense activity will result in greater ultimate memory but greater temporary inhibition against recall.

The experimental hypothesis which tests consolidation theory stated simply is that "due to the phenomenon of perseverative consolidation, a pattern perceived under high arousal should show stronger permanent memory and weaker immediate memory than a pattern accompanied by low arousal" (Kleinsmith and Kaplan, 1963, p. 190). The phenomenon has been demonstrated in a variety of experimental conditions, including arousal manipulated by learning material (Kleinsmith and Kaplan, 1963), delayed auditory feedback (King and Wolf, (1965), white noise (Berlyne, Borsa, Hamacher and Koenig, 1966, McLean, 1968), drugs (Batten, 1967), and film content (Levonian, 1967). A review of these and other studies stimulated by consolidation theory are presented in the following section.

Research Stimulated by Consolidation Theory

Kleinsmith and Kaplan, 1963

These investigators ran 48 undergraduate students individually in two sessions, learning and recall. During the initial session, the S was presented a list of eight word-digit pairs. The eight words that were expected to produce different arousal levels were: KISS, RAPE, VOMIT, EXAM, DANCE, MONEY, LOVE, SWIM. The S first saw the stimulus

word alone for four seconds, and then the stimulus word and response digit (2-9) together for the next four seconds, after which the second pair was presented in like manner. A colour naming task was interpolated between pairs in an attempt to separate the arousal effects of one pair from those of the next. The indicant of arousal employed was the galvanic skin response (GSR).

Each of Kleinsmith and Kaplan's Ss was instructed to concentrate on the word-digit pairs and the colors as he called them out loud, but to avoid rehearsal, he was not told specifically that he would be tested for recall. During the recall session the S was instructed to call out the correct digit for each stimulus word as it appeared. The correct digit was not repeated. Colour naming was again used as an interpolated task. Each S was run in only one recall session. The recall sessions followed the initial presentation of the pairs by 2 minutes, 45 minutes, one day or one week. Any drop in the S's skin resistance which occurred within four seconds of the presentation of the stimulus material was considered as an arousal value. These eight values were ranked with the lowest four designated as "low arousal" and the highest four as "high arousal" learning. With percentage of digits correctly recalled as the criterion score, the interaction between arousal level and recall interval was significant at the 0.01 level. Low arousal resulted in better short-term retention, whereas high arousal resulted in better long-term retention.

Low arousal associates were recalled five times as often as high arousal associates when recall was assessed at the two-minute interval. With a recall interval of 20 minutes the two arousal conditions were

indistinguishable in terms of recall performance. This trend, forgetting on the part of low arousal associates and reminisence on the part of high arousal associates continued to the last recall period where the recall levels for high and low arousal associates were separated in reverse by a magnitude similar to that of the two-minute recall interval. Low arousal associates showed consistent forgetting over time. High arousal associates were recalled significantly less often when tested shortly after learning, but showed a reminiscence effect of over 400 per cent in the one-week interval.

Kleinsmith and Kaplan (1963) interpreted these findings as providing further support for the theory of reverberating neural circuits. They provided a somewhat simplified physiological explanation of the processes involved which they pictured as follows:

> When a person perceives a pattern, a closed reverberating neural circuit is set up in his brain corresponding to this pattern. The more nonspecific neural activity or arousal present, the greater the number of times which the trace is likely to reverberate. And the greater this perseverative consolidation of the neural trace, the stronger the permanent memory.
>
> However the apparent paradox is that while perseveration is taking place, recall ability is poor. This follows from the hypothesis that at any given instant the neurons involved in the perseverating trace are either already in the process of firing, are in an absolute refactory state, or may be in a state of slowly developing subthreshold activity (Hodgkin, 1948); thus the trace would be relatively unavailable to the organism. With greater arousal there will be increased perseveration and thus poorer immediate performance (p. 192).

Although Kleinsmith and Kaplan's explanation coincided with their empirical findings, the experiment attracted much criticism on the grounds that the meaningfulness of the learning material could have mediated learning irrespective of arousal. Such an alternative explanation does not seem particularly valid in view of their results, since it would predict higher

recall for strong association-value words across all time conditions and thereby cannot explain the interaction found between arousal at the time of presentation and recall as a function of time.

Kleinsmith and Kaplan, 1964

To show that the arousal-recall time interaction phenomenon is independent of the association values or unique qualities of the words involved, Kleinsmith and Kaplan repeated their experiment. While recording skin resistance as a measure of arousal, they presented 36 Ss with six (zero per cent association value) nonsense syllables paired with single digit numbers following the same procedure used in their earlier study except that the Ss were tested at two minutes, twenty minutes or one week after the initial presentation of the pairs. The results were virtually identical with those of their first experiment. Nonsense syllable paired associates learned under low arousal exhibited high immediate recall and rapid forgetting. High arousal associates exhibited a marked reminiscence effect, low immediate recall and high delayed.

Walker and Tarte, 1963

A replication of the Kleinsmith and Kaplan (1963) study was conducted by Walker and Tarte as a test of whether similar results would obtain with homogenous lists of high and low arousal words. Seventy-two Ss were divided into nine groups. Learning consisted of one trial with a list composed of eight stimulus words and single digits as responses. Three groups learned a high arousal list, three a low arousal list, and three learned a mixed list consisting of four high-arousal and four low-arousal items. Within each list type, one group recalled the list at two minutes, one group at forty-five minutes, and one group at one week.

The low-arousal list showed high immediate recall which decreased with time. The high-arousal list showed some rise in recall with time. Other analyses in which data from the three lists were pooled agreed essentially with the results of Kleinsmith and Kaplan (1963) showing high immediate and low delayed recall for low-arousal items, and low immediate and high ultimate recall for those items learned under high arousal. Although the initial separation in magnitude of recall scores between high and low arousal items was considerably less than that obtained by Kleinsmith and Kaplan, the differences between high and low arousal conditions were significant.

McLean, 1968

A recent replication of Kleinsmith and Kaplan's (1964) study was designed by McLean to determine whether the arousal-recall time interaction phenomenon could be demonstrated when arousal was manipulated independently of the learning material by means of white noise presented at 85 decibels (db). A futher purpose of McLean's investigation was to assess the effects of individual differences in Extraversion on paired-associate recall performance as a function of the recall interval employed. In addition, McLean wished to discern whether the interaction phenomenon could be produced with intentional as well as incidental learning.

McLean's first experiment was an exact replication of Kleinsmith and Kaplan's (1964) study with one exception: to half of the Ss white noise was presented simultaneously with the pairings of the stimulus syllable and response digit. The second experiment was identical with the exception that the Ss were made aware of the nature of the study through the inclusion of appropriate instructions. Skin resistance recordings showed that white noise was effective in inducing arousal. A significant inter-

action was found ($p = 0.05$) between noise and recall interval in both types of learning in the direction predicted by the theory of perseverative consolidation. When noise conditions were collapsed, however, and the recall of associates compared as a function of the within S arousal present during the associative phase of learning; i.e., Kleinsmith and Kaplan's scoring procedure based on skin resistance decrements, a similar interaction was found in the incidental learning experiment, but failed to reach statistical significance in the second (intentional learning) experiment. McLean (1968, p. 163) pointed out that in the second experiment, "the familiar performance depression on the part of high arousal associates reappeared during the 2 minute recall session but the recall performance was identical for high and low arousal associates during the delayed recall session." He further stated that, "It cannot be said that high arousal as assessed by skin resistance during P-A presentation in experiment 2 had no effect on delayed recall performance since the relative superiority (24%) of the white noise group during delayed recall discounts such a conclusion. Instead it can only be assumed that the use of skin resistance to allocate P-As into arousal categories is less sensitive under conditions of intentional learning."

Eysenk's theory that introverts function at relatively higher levels of arousal was supported by McLean's investigation. He found that introverts performed relatively poorly on the immediate retention test, but reminisced to a greater degree than did extraverts who performed optimally immediately and poorly on the delayed recall test. This interaction between personality and recall interval was statistically significant ($p = 0.01$). Furthermore, it was found that personality derived arousal (introversion-extraversion) and experimentally induced arousal (white noise)

were additive in their effect on paired-associate recall performance.

Batten, 1967

This investigator thought it seemed "highly desirable to manipulate arousal in such a way so as to preclude the confounding effects of general arousal level and the effects of emotional loading of particular words which are used simultaneously as stimuli in the learning task" (p. 1056). Thus, Batten employed only common "neutral" words (PAPER, AMONG, FAR, UPON, SUCH, MOST, BACK, and THAN), and arousal was manipulated both pharmacologically and experimentally. Ss in the high arousal group took 10 mg. dexedrine one hour before the experimental session. In addition, psychological manipulation of arousal was effected by including in the instructions to the high arousal group at the time of testing remarks designed to create uncertainty ("we're going to see how you really operate") and some degree of ego involvement ("performance on this task is related to intelligence"). Further, high arousal Ss were given the Stroop (1935) test which produces a strong conflict of response tendency. Low arousal Ss took 100 mg. phenobarbital one hour prior to the experimental period, and were given instructions "designed to minimize uncertainty and ego involvement." Also, they did not perform the Stroop test.

Batten employed 120 Ss altogether and assigned them randomly to 10 groups - 2 groups for each of 5 recall intervals (2 minutes, 20 minutes, 45 minutes, 1 day, 1 week). Paired associates were presented on slides in a sequence like that used by Kleinsmith and Kaplan (1963) described above. Batten's results "strongly resemble" those reported by Kleinsmith and Kaplan (1963), but a test of mean differences yielded no significance. Batten argued that "large intra-group variance precludes significance"

(p. 1057), but made no attempt to account for that variance. The results of McLean's work cited above (See p. 13) suggest that personality differences may well have contributed greatly to that large intra-group variance.

Batten interpreted his results as "supporting the contention that general CNS arousal level, and not simply characteristics inherent in the words or syllables presented, affects recall" (p. 1058). Such an interpretation, although psychopharmacologically appealing, is purely contentious, however, since arousal levels were not monitored during the actual experimental sessions. Rather, "the effectiveness of these procedures in producing the desired arousal effects was ascertained in a pilot study involving repeated measures on six Ss" (p. 1056). Batten also reprted that the mean difference in skin conductance between conditions was 16.6 micromhos. Criticism is warranted here on at least two counts. The use of absolute measures of skin conductance rather than changes in conductance is open to question because of wide individual variability in skin conductance. Secondly, it cannot be assumed that differences between high and low arousal conditions similar to those found in the pilot work obtained with the experimental Ss. It is possible that certain Ss within the high arousal condition responded in a manner not unlike that of Ss in the low arousal condition.

There was another equally important consideration which strongly indicated that the absence of physiological measures in the Batten study was a major error of omission. For the 20 and 45 minute recall interval groups, Batten had the Ss remain in the laboratory. During that time, high arousal Ss were given an irrelevant difficult task (tracking a pursuit rotor while viewing the disk through a mirror). Low arousal Ss were left in a darkened room (having been told that this was to check on the

effect of dark adaptation). The hypothesis which Batten reportedly was testing ("paired associates learned under low arousal will show high recall soon after learning but rapid forgetting; with high arousal recall will be poor at first but better at the longer intervals") implied that it was the arousal level at the time of learning which supposedly would affect subsequent recall. By treating the high and low 20 and 45 minute recall groups differently in the period between learning and recall, Batten has undoubtedly confounded the effects on recall of arousal during learning, immediately after learning, and prior to recall. Thus, because of this confounding effect, as well as the shortcomings of Batten's experiment referred to above, no definite conclusions can be drawn from the results of his research. It did suggest, however, that the effects of pharmacologically produced arousal should be separately ascertained in a manner which would preclude any confounding with the effects of experimentally induced arousal. In addition, Batten's work pointed to the necessity of determining the effects of arousal on recall in terms of the point in the learning-recall sequence at which arousal is experimentally manipulated.

Levonian, 1967

In part, at least, Levonian attempted to determine if the relationship between arousal and recall, when arousal precedes information presentation, is the same as that which obtains when arousal follows information presentation. Levonian (p. 104) stated that "it cannot be assumed that arousal which follows information presentation, as is the case in the Michigan (Kleinsmith and Kaplan) studies, has the same effect on retention of that information as does arousal which precedes information presentation, as is often the case with continuously-presented classroom

material." Thus, Levonian set out to determine empirically whether Kleinsmith and Kaplan's (1963, 1964) results would emerge under typical classroom conditions. He was able to avail himself of a "real" classroom situation, and on the day that a traffic safety film was scheduled for showing in four high school driver education classes, skin resistance measures were obtained from each of 83 pupils during the actual viewing of the film. A questionnaire was administered immediately after the film presentation, as well as one week later. Each of the 15 items on the questionnaire pertained to information presented at a specific point in the film. With this as the mid-point of a one-minute interval, high arousal for a given student was defined as a resistance decrement larger than half a standard deviation, as based on his total (16080) resistance values standardized to unit variance. Results indicated that, even with continuously presented material, information presented during high arousal showed poor short term retention and enhanced long term retention with low arousal arousal showing the converse. Specific implications of the results are spelled out by Levonian (p. 111) as follows:

> The results imply that the effect of arousal induction on retention is independent of the mediator of the arousal increment: an identification was not made of the arousal mediators, which may have been thoughts, film material, change in student position, etc. The study made no distinction between an arousal increment whose mediator was known (or presumed to be known) and an arousal increment whose mediator was not known.
>
> In particular, the results imply that an arousal increment which enhances the retention of Information A need not be mediated by Information A. This point is supported by the fact that even when an arousal increment preceded information presentation, a large increment enhanced long-term retention.
>
> If the mediator of arousal induction is irrelevant, it would seem that the effect of arousal induction on retention is independent of the emotion associated with the arousal.

Delayed Auditory Feedback Studies

Consolidation theory has received some additional support from a series of studies conducted by King and his associates in which arousal was experimentally produced in a manner external to the learning situation. His method of arousal induction was that of delayed auditory feedback (DAF). As a result of an initial investigation in which King (1963) demonstrated that the immediate recall of connected, meaningful material practised under 0.2 seconds of DAF was significantly poorer than that practised under control conditions, several important issues arose.

King and Wolf (1965). One question pertinent to the present consideration of studies stimulated by consolidation theory was raised by King and Wolf (p. 131): "If DAF does increase emotionality or arousal, a delayed recall test should reflect an increase in retention of the material practised under DAF." To determine if such were the case 42 Ss were run in one experimental and two control conditions. The Ss recalled a short story (5 paragraphs, 221 words) immediately after reading it and again 24 hours later. The physiological indicants of arousal monitored during the reading were pulse rate and GSR.

The experimental group was subjected to 0.2-second DAF in the middle section of the story. Shock of a moderate voltage was administered to the Ss in one control group when they reached that part of the story at which Ss in the experimental group were subjected to DAF. The other control group received neither DAF nor shock during the reading of the story. Both the experimental group and the control group that recieved shock showed marked changes in GSR measurements during the reading of the middle section of the story. With respect to pulse rate, no significant differences were found between the three sections of the story. Separate tests

for each group, however, indicated that there were significant mean decreases in pulse rate for the experimental group and the control group (which received neither DAF nor shock) between the second and third sections of the story.

Immediate recall scores were significantly poorer for the experimental group as contrasted with those of each of the control groups. This effect was due almost exclusively to differences in recall of the middle section of the story. No significant differences were found among the three groups for accuracy of delayed recall. The major change in the delayed recall scores compared with the immediate ones was a sharp increase in the accuracy of recall of the middle section by the experimental group. Thus, the delayed recall test did reflect an increase in the retention of material practised under conditions of DAF. Such a finding is directionally consistent with predictions from consolidation theory.

King and Dodge (1965). These investigators repeated the King and Wolf study but used verbal recall rather than written. Similar results were found, although the effects were somewhat weaker.

Harper and King (1967). An additional variable, that of time of auditory feedback delay, was manipulated in this further investigation of the effects of DAF on immediate and delayed recall. Three groups of 20 Ss read and later recalled a short story. The two experimental groups had a portion of the story presented under DAF; one group had a delay of 0.2 seconds; the other, 0.8 seconds. Immediate recalls were gathered from all Ss. In addition, half the Ss gave a 15-minute delayed recall while the other half gave a 30-minute delayed recall. Significant differences ($p = 0.05$) were found in immediate recall scores, especially of the critical second para-

graph, between the two experimental groups and the control group. Mean recall scores for the two experimental groups were both approximately 14, whereas that of the control was 25. No increase in recall was reported for either experimental group at the 15-minute or 30-minute test.

With reference to their findings Harper and King (1967, p. 432) stated, "Clearly, the 15- and 30-minute time periods were not adequate to allow whatever processes are operating in the increase in delayed retention." Their results are not surprising, however, when contrasted with those of Kleinsmith and Kaplan (1964) wherein it was found that the reversal of high arousal and low arousal recall scores became apparent between the 20-minute and 24-hour intervals.

Williams and Frinke (1968). These investigators designed a study to test King and Dodge's (1965) hypothesis that if delayed recalls alone were obtained, material presented under DAF would be recalled better than would material not presented under DAF. They had 40 Ss read 36 nouns aloud 6 times under conditions of 0.2-seconds DAF, 40 under conditions of synchronous auditory feedback, and 40 under conditions of no-apparatus. No differences at significant levels between the three groups were noted in recognition performance. For all groups delayed (24 hours) test scores were lower than immediate test scores. No treatment x recall interval interaction was observed for recall or recognition.

Williams and Frinke's results, then, did not support the hypothesis being tested. In addition, these researchers stated that their results question the generality of the findings of King and Wolf (1965) and King and Dodge (1965) as well as those of Kleinsmith and Kaplan (1963) and Walker and Tarte (1963). However, Williams and Frinke, themselves, pointed

out that, in addition to the obvious differences in materials and learning task between their experiment and those whose results they question, there are "potentially important procedural differences." In their study the S was exposed to the learning material six times, while a single exposure was used in the previous experiments. Also their study used the intentional approach rather than the incidental approach to learning. They were not clear as to how these differences would change predictions based on the hypothesis advanced by Walker and Tarte (1963). On the basis of McLean's findings (See p. 13), it can be assumed that an intentional learning procedure does not demonstrably change the predictions, but may possibly weaken the interaction effect.

Other procedural differences notwithstanding, the most critical procedural difference between Williams and Frinke's investigation and those whose results they question is the failure on the part of Williams and Frinke to monitor any physiological indicants of arousal. Since King and his associates did not use their physiological data in a very meaningful way, the omission of such data from Williams and Frinke's study does not preclude a rough comparison being drawn bwteen the results of their investigations. It must be stated, however, that without physiological indicants of arousal one cannot assume that the S was aroused under conditions of DAF and synchronous auditory feedback and not under conditions of no-apparatus. Thus no meaningful comparison can be made between the results of Williams and Frinke's investigation and those of Kleinsmith and Kaplan (1963) and Walker and Tarte (1963) wherein physiological measures of arousal were employed.

Berlyne and His Associates, 1965, 1966

Berlyne and his associates were the second research team to investigate the effects of arousal on immediate and delayed recall using an arousal producing procedure which was external to the learning material. In their 1965 publication, Berlyne, Borsa, Craw and Gelman reported two experiments. In the first, Ss were required to learn a list of paired-associates by the anticipation method in three presentations. During the presentation Ss were exposed to one of three noise conditions: 72 db white noise, 58 db white noise, no noise. On testing immediately after the presentation of the paired-associates, it was found that the 58 db group recalled slightly more associates than did the no noise-group. The 72 db noise group, however, showed a significant impairment in recall. These findings are consistent with those of Kleinsmith, Kaplan and Tarte (1963) which presented an inverted "U" relationship between arousal and recall performance when the retention test followed immediately after learning.

In the second experiment reported by Berlyne and his associates (1965), the above procedure was also employed with the addition of a delayed (24 hours) recall test. When white noise groups were collapsed and compared with the no-noise group, it was found that the noise group's immediate recall was significantly poorer than the no-noise group. The effect was completely reversed when recall was tested the following day. Their results, then, are consistent with those of previous studies in which the arousal-recall interval interaction phenomenon was demonstrated. Nevertheless, a criticism is in order: no physiological measures were employed; therefore, the assumed increase in arousal under conditions of white noise is merely hypothetical.

In 1966 Berlyne, Borsa, Hamacher and Koenig designed a study to determine the crucial time during which "arousal" has a facilitative effect on recall. The procedure outlined above was again used, although in this study four noise conditions were employed: (1) white noise (75 db) during the stimulus and the stimulus-response pairings; (2) white noise during the intertrial intervals; (3) continuous white noise; (4) no noise. Results indicated that white noise during the presentation of the stimulus and response increased recall when recall was one day later. Arousal during stimulus onset did not influence immediate recall, and white noise after the stimulus and response did not affect immediate or delayed recall. Since the relationship which obtained between "arousal" at the time of paired-associate presentation and enhanced delayed recall was statistically significant ($p = 0.05$), it can be concluded that these results partially support predictions from consolidation theory. The criticism of the first two experiments reported by Berlyne and his associates (1965) is equally applicable here, however. Unless physiological indicants of arousal are employed, it cannot be assumed, with any great deal of assurance that differences in recall are attributable to differences in arousal.

Malmo's Activation Hypothesis

Malmo (1959, p. 367) points out that there have been three main lines of attack when it comes to the problem of activation: "(a) through electroencephalography and neurophysiology, (b) through physiological studies of "behavioral genetics", and (c) through the learning theorists' search for a satisfactory measure of drive". It is Malmo's own neuropsychological approach which provides part of the theoretical backdrop

for the present investigation. It should be first pointed out that, in using the term, "activation", Malmo is referring to the "intensive dimension" of behavior, and that the term, "arousal", is often used interchangeably with "activation". This neuropsychological dimension is described by Malmo (1959, p. 384) as follows:

> The continuum extending from deep sleep at the low activation end to "excited" states at the high activation end is a function of the amount of cortical bombardment by the ARAS, such that the greater the cortical bombardment the higher the activation. The shape of the curve relating level of performance to level of activation is that of an inverted U: from low activation up to a point that is optimal for a given performance or function, level of performance rises monotonically with increasing activation level; but past this optimal point the relationship becomes non-monotonic: further increase beyond this point produces fall in performance level, this fall being directly related to the amount of the increase in level of activation.

Schematically, the paradigm for experimental purposes which Malmo proposes is:

Activation Level:	Low	Moderate	High
Expected Performance Level:	Low	Optimal	Low

On the surface of it, this paradigm seems to be at variance with predictions from consolidation theory. It should be borne in mind, however, that Malmo has not been, either theoretically or empirically, directly concerned with the study of memory. When the prediction of an interaction between arousal level and recall interval generated by Walker's (1958) action decrement theory is cojoined with Malmo's activation hypothesis, the following relational matrix ensues:

Arousal Level:	Low	Moderate	High
Malmo's Expected Performance Level:	Low	Optimal	Low
Expected Immediate Recall Level:		High	Low
Expected Delayed Recall Level:		Low	High

With Malmo (1959, p. 376),

> It is important to keep in mind that the measure denoted by "moderate activation level" has meaning only in relative (not absolute) terms. That is, the level is "moderate" because it is higher than that of the low activation condition, and lower than the level of the high activation condition.

It was this consideration of relativity which provided the rationale for incorporating predictions from consolidation theory into the lower right-hand four cells of the above matrix rather than the two lower cells of the first and third columns.

Inspection of the matrix shows that Malmo's expected performance level is not dissimilar to expected immediate recall level if "optimal" and "high" are considered to be relative terms. Thus, the two hypotheses are not incompatible when performance on an immediate test is differentiated from delayed performance. Some investigators (McLean, 1968, Kleinsmith, Kaplan and Tarte, 1963) have chosen to discuss the predicted outcomes in terms of "performance" on the immediate test and "learning" on the delayed test. Kleinsmith *et al.*, (1963) found that when the "confounding effects of active consolidation are eliminated by using a long-term rather than a short-term recall interval, a strong positive correlation between learning and arousal is obtained" (p. 396). Further, they stated that:

> The results of the present experiment coincide well with the empirically known facts that although a person may actually "freeze" and perform very poorly in a highly arousing situation (inverted-U relationship between arousal and performance), a person also tends to remember most vividly those incidents in his life which were most traumatic or arousing (positive relationship between arousal and learning).

It is not one of the purposes of the present investigation to resolve the difficulties that surround the learning-performance distinction, but it should be appreciated that differentiating between immediate and delayed recall performances may well be a fruitful empirical approach to the untangling of performance and learning.

Empirical tests of Malmo's activation - expected performance paradigm have employed electrophysiological monitoring of activation (arousal) level. Such indicants of arousal have ranged from galvanic skin response (GSR), heart rate, blood pressure, respiration, to electroencephalographic (EEG) alpha rhythm. Until recently, the latter measure was often the measure of choice among neurophysiologists. Now, however, "neurophysiological findings strongly suggest that it may be possible to achieve more precise measurement of activation through a direct recording of discharge by the ARAS into the cerebral cortex" (Malmo, 1959, p. 385). Unfortunately, such a procedure has not always been possible. Electrophysiological recording techniques more macro in nature, however, have been used to advantage. And, if we can assume with Malmo (1959, p. 384) that "local increase in muscle tension somehow produces an increase in the general activation level, with rise in heart rate and blood pressure, with fall in level of EEG alpha, and so on", then tentative conclusions can be drawn from earlier studies concerned with the effects of muscular tension on memory functioning.

Muscular Tension and Recall: Research

Experiments relating muscular tension to recall are perhaps the first investigations of the effects of arousal on memory. Smith (1953), for instance, found that muscular tension declines more following a completed than an incompleted task. Similarly, Forrest (1959) found that the muscular tension associated with an incompleted task was greater than that associated with a completed task. In addition, he found that there was a greater recall of incompleted tasks under nontension conditions, and greater recall of completed tasks under tension conditions.

Earlier investigators of dynamogenic factors influencing recall (Courts, 1939, 1942) often had Ss learn verbal material while squeezing a dynamometer. Their recall was then compared with a group who had learned without any increased muscular tension. Bourne (1955) used a procedure so that the effects of tension on learning could be separated from the effects on retention. Tension (T) was applied or withheld (N) during both the learning and recall phases of the experiment. Four experimental groups (T-T, N-N, T-N, N-T) were established and five recall intervals (0, 30, 60, 120, 240 seconds) were employed. He found that differences in recall between T-N and N-N and between T-T and N-T were not significant at the longest time interval of four minutes. In other words, tension applied during learning had no effect on recall when tension was controlled during the recall phase. On the other hand, there were significant differences in recall between the N-T and the N-N groups, and between T-T and T-N groups. Recall under tension was better than under neutral conditions when degree of tension during original learning was controlled.

In discussing his results, Bourne argued that previous differences in recall under conditions of tension during learning were caused by the tension persisting until the recall period. His findings seem to confirm this interpretation. Over time the differences in recall between T and N groups (learning) steadily decreased. After four minutes tension applied during learning was expected to be completely dissipated; at that point recall was found by Bourne to be almost identical between groups learning under the two different conditions. He concluded that "tension facilitates response elicitation but does not alter habit strength" (p. 421).

Bourne interpreted his results within the Hullian (Hull, 1943) behavioral framework and sees them as being in accord with the concept of tension as drive. Malmo and students of activation (arousal) theory would view Bourne's results differently: "activation does not fit very well into the S-R formula" (Malmo, 1959, p. 385). "As the product of interaction between internal (perhaps hormonal) conditions and external stimulating ones, activation cannot be very reasonably classified as either stimulus or response" (Malmo, 1959, p. 374). Elsewhere (p. 370) Malmo states:

> It is tempting to conclude that tension induction is simply one of the many ways to increase activation level, but as Courts' (1942) discussion suggests this conclusion would be premature. It is possible that squeezing on a dynanometer, a typical means of inducing tension in these experiments, may produce generalized activation effects.

To determine if such were the case, Malmo suggests that the induced tension experiments be repeated with simultaneous recording of EEG and other physiological functions. The above suggestion notwithstanding,

Malmo later states, "generalizing from the induced tension experiments (conducted by Malmo and his associates to assess the effects of increased activation on localized skeletal-muscle tension in psychiatric patients), it seems reasonable to suppose that a patient's muscular tension in a small focal area might have the general effect of increasing activation" (p. 383).

When Malmo's supposition is taken into consideration, Bourne's results can be tentatively interpreted to mean that increased arousal, generalized from focalized muscle tension produced by gripping the dynanometer, facilitated recall since recall under "tension" was better than under neutral conditions. A replication of Bourne's (1955) study with the employment of appropriate physiological indicants would be required, however, before the above interpretation of his results could be considered anything more than mere conjecture. Unfortunately, it was not within the confines of the present investigation to conduct such a replication. The use of an arousal producing agent, the Rapid Discrimination Task (RDT), external to the learning material, which has been shown to increase local muscle tension, however, provides for rough comparisons of results (See Chapter IV).

Rationale for Use of Rapid Discrimination Task and "The War of the Ghosts"

Levonian (1967), cited above, set out to determine empirically whether the interaction between arousal level and recall interval found in the Michigan studies would emerge under typical classroom conditions, "typified by lecture or film". It will be recalled that Levonian used the film condition in his investigation. It should be borne in mind,

however, that the use of films in the classrooms of today is still not that prevalent, and secondly, that the lecture is not the only alternative to the film for presenting information which is to be remembered. McLuhan's (1964) contentions notwithstanding, the printed word continues to be the major medium in which information is conveyed in the present elementary and secondary school systems. It is in this form that "The War of the Ghosts" was presented to subjects in the present investigation.

The rationale underlying the use of "The War of the Ghosts" is threefold. First, it was assumed that none of the Ss would be familiar with the story since it is not readily available unless a search of the literature pertaining to the study of memory is embarked upon. Secondly, as pointed out by Paul (1959, p. 9), "many of its episodes and themes are peculiar to Indian folklore, and to people not familiar with this folklore, the story is cryptic and the events seem unconnected". Thus, not only the content, but also the style, would be unfamiliar to the Ss. Thirdly, a scaling and factor analytic study of written recalls (the method also employed in the present study) of "The War of the Ghosts" was available (King, 1960). A major methodological difficulty encountered in the study of memory for connected, meaningful material is that of a rationally based system of measuring the accuracy of recall. In view of the fact that King demonstrated a method for establishing the empirical validity of various scoring procedures using "The War of the Ghosts" as the to-be-remembered material, it seemed only reasonable to use the same stimulus material. For these reasons, then, "The War of the Ghosts" lent itself well to the purpose of the present study.

Although it was not one of the stated purposes of this investigation to determine the applicability of the arousal recall interval interaction to educational practice, it is one of the obvious directions in which such a research finding could travel. Thus, a task not too unlike those presented to school children was in order. The discrimination required of the subject in the Rapid Discrimination Task (RDT) originated by Belanger (1957) is not that dissimilar to some typical tasks engaged in by school children. Such similar tasks range from certain "reading readiness" tests used in Kindergarten to discrimination of geometric forms and the areas thereof required in Junior High School Mathematics classes. Perhaps more important than this consideration of application of results, was an interest in determining whether the arousal recall interval interaction could be demonstrated through the use of an external arousal producing agent other than DAF or white noise. Because of certain research findings which will be presented below, the RDT seemed well suited to such an empirical test.

Research conducted by Malmo and his associates (Malmo, Shagass, Belanger and Smith, 1951; Malmo, Shagass and Davis, 1951), as well as that of the originator of the RDT, Belanger (1957), indicated that such a task would produce the desired change in arousal level. The original version of the RDT was described by Belanger as follows:

> La situation éxperimentale s'agit d'une épreuve de discernement rapide des dimensions. Le sujet est assis dans une chambre à demi-obscure. Devant lui se trouve un écran sur lequel on projette successivement des images représentant six cercles dont les dimensions varient légèrement. Il doit découvrir lequel des cercles est plus grand et le désigner par son numero avant que l'image suivant soit projetée.

> Il a les doigts posés sur des boutons fixés sur les bras de sa chaise. Tout en donnant sa répose à voix haute, il doit presser sur l'un de ces main gauche (selon les instructions). S'il fait une erreur ou ne répond pas à temps, l'experimentateur l'avertit au moyen d'un timbre (buzzer). L'épreuve comprend trois series consecutive de vingt images, séparées l'une de l'autre par des périodes de répos de 60 et 45 secondes, durant lesquelles on demand au sujet de demeurer absolument immobile. La première série est présentée sans arrêt au rythme de cinq secondes par image, ce qui donne à la majorité des sujets assez de temps pour emettre un jugement. Le temps de présentation est diminué à trois secondes par image pour la deuxième série et à deux secondes pour la troisième, ce qui rend la tâche très difficile (Belanger, 1957, p. 114).

In the present study a modified version of the RDT was used. This version incorporated two major changes. First, to control as much as possible for the effects of experimenter-subject interaction, which have been expertly investigated by Rosenthal (1966), the S was not required to produce a verbal response. It has been found that arousal level, as reflected in pupillary activity, is not demonstrably different for a key press as compared with a verbal response when the stimuli are ambiguous and non-ambiguous MMPI items responded to with either a verbal or coded key press designating "true" or "false" responses (Sweeney, 1968). Thus, button responses were employed. A second modification was made in the RDT when results of pilot work indicated that the successive presentation of 20 slides each at 5, 3, and 2-second rates would be too lengthy for the purposes of the present study. One, immediate recalls were not obtainable until almost 20 minutes after the presentation of the story. Two, problems of habituation of physiological responses became apparent, especially with the use of a 5-second slide presentation rate. The 2-second presentation of 30 slides appeared optimal both for arousal induction purposes as

well as for allowing for earlier immediate recalls. These two procedural changes, then, constituted the modifications made in the RDT for its use in the present study.

As for the RDT's arousal producing properties, these were demonstrated in the pilot study as well as by Malmo et al. (1951a) who found that mean arm tension rose during performance on the RDT. It should be pointed out that these electromyographic (EMG) data reflect much more tension than that required to press the response button. An experiment was carried out by Belanger (1957) to determine whether the increase of tension in the forearm muscles during the RDT could be attributed to the repeated finger movements rather than to the difficulty of the perceptual task. Accordingly, the latter was reduced to the simple perception of clicks sounded at regular two-second intervals. The S was required to press the button each time he heard a click. Under these conditions there was no evidence of gradients in the muscles observed. Belanger (1957, p. 121) concluded that, "the gradient phenomenon is related, not to the motor aspects of the task, but to its psychological difficulty". It should also be pointed out that increases in muscle tension during performance on RDT was found to be practically independent of accuracy of perceptual performance (Malmo et al., 1951b). Furthermore, these investigators found that the RDT produced a significant drop in the number of circulating lymphocytes. If it can be assumed, as it was by Malmo and his associates (1951b), and it is probably a valid assumption when the extensive research conducted by Selye (1956) is taken into account, that an objective indication of arousal is produced by the lymphocyte count, then the RDT seems to be an appropriate method of increasing arousal.

To ensure that such was the case, however, physiological reactivity was monitored in the present investigation. Two physiological indicants were chosen: heart rate (HR) and breathing rate (BR).

Rationale for Use of Two Arousal Indicants

The concepts of individual response specificity and stimulus specificity provide the rationale for using two measures of arousal rather than only one. These concepts have been borrowed from the field of psychosomatic medicine. According to Lazarus (1966, p. 378), "a sensitive organ system will lead to symptoms in that system when threat from any source is prolonged or chronic". He adds that the implication of such individual response specificity for physiological measurement is that it is important to know, for any given individual, his most sensitive or reactive autonomic indicator in order to compare his degree of threat with that in another. For example, if the sensitive system is respiration and the experimenter is measuring heart rate exclusively, a somewhat misleading estimate of arousal would be obtained.

Stimulus specificity is a version of the concept "that each kind of threat produces its own characteristic pattern of symptoms" (Lazarus, 1966, p. 376). Studies conducted by Lacey, Kagan, Lacey and Moss (1963) provide significant support for the principle of stimulus specificity. They proposed that "cardiac deceleration accompanied and perhaps even facilitated ease of "environmental intake, whereas cardiac acceleration accompanied or facilitated rejection of the environment" (Lacey et al., 1963, p. 165). Since the design of the present study allowed for informal tests of Lacey's proposal, predictions from it were incorporated as ancillary expectations.

Rationale for Use of Recollection Rating Scale

Not only for purposes of determining whether Lacey and his associates' (1963) proposed acceptance of environment-cardiac deceleration, rejection of environment-cardiac acceleration phenomena could be demonstrated in the present study, but also because an accepting attitude may well be more conducive to better retention than a rejecting one, it seemed desirable to attempt some kind of assessment of the individual subject's "frame of mind" during the experimental session. Although the construct herein employed is that of "arousal" rather than "anxiety", with Hanfmann (1964, p. 63),

> I would like to express my conviction that psychological methods of producing and studying anxiety represent very promising avenues of approach to the problem, but that their promise cannot be fulfilled without much more attention being devoted to the analysis of the inner state of each individual subject at the time of testing and of his personal definition of the situation and its meaning in the experimental setup.

Within the confines of the present investigation, this is equivalent to saying that a more phenomenological approach to the study of the effects of arousal on retention is in order, or to advocating that some aspects of the clinical method of investigation be incorporated into the experimental design. A factor-analytic study of the components of emotion conducted by McCarter (1961) lent itself to such an end.

McCarter designed his investigation to determine the components of emotion and to correlate those components with psychiatric diagnoses. He had 415 college students rate 80 recalled affects. Intercorrelations of the ratings generated an 80 x 80 matrix. Factor analysis yielded four bipolar orthogonal factors: pleasantness - unpleasantness, arousal - indifference, acceptance - rejection, and comprehension - puzzlement.

The factor structure supported the activation theory of emotion.

In his second experiment, McCarter had 40 sociopaths, 16 alcoholics, 10 organics, 13 paranoid schizophrenics, and 23 normals rate the emotion in their own early recollections on scales derived from the four above-mentioned primary emotional factors. The comprehension factor discriminated best between the recalled emotion of normals and those of the clinical groups. Although, for purposes of the present investigation, such a difference was not of any major importance since only normals were employed, it was conjectured that it would be that axis (comprehension) that would discriminate between those subjects who were to be exposed to the arousing situation (RDT) during the experimental session and the control Ss. It was also expected, of course, that the arousal dimension would discriminate between the above mentioned two groups.

In addition to allowing for the making of such predictions, the Recollection Rating Scale (RRS), as a phenomenological instrument, allowed for the assessment of the individual's "inner state" during the experiment proper. Because of the nature of the experimental design only a tool such as the RRS which used recollections could be employed.

Integration of the Literature and Statement of Hypotheses

The major theories of memory which were surveyed included those of trace, interference and consolidation. Trace theory has not attracted much attention since McGeoch's (1932) major attack. And, although interference has been shown to be a fertile explanation of forgetting (Postman, 1961), it offers no clues to an understanding of incremental changes which occur in the memory process. Consolidation theory, on the other hand, provides an explanation of the development of memory.

Present day consolidation theory has as its base Walker's (1958) action decrement theory. This is a general theory which interrelates perseverative consolidation, action decrement and arousal. The theory proposes that the occurrence of any psychological event results in a perseverative trace process which gradually establishes permanent memory at the expense of immediate memory (a process which serves to protect the consolidating trace from immediate interference) and that an increase in arousal during the associative event will produce a more intense trace activity, thus rendering the association less available for immediate recall while consolidating it for greater permanent memory (Walker and Tarte, 1963).

The experimental hypothesis which tests consolidation theory stated simply is that "due to the phenomenon of perseverative consolidation, a pattern perceived under high arousal should show stronger permanent memory and weaker immediate memory than a pattern accompanied by low arousal" (Kleinsmith and Kaplan, 1963). The phenomenon has been demonstrated in a variety of experimental conditions, including arousal manipulated by learning material (Kleinsmith and Kaplan, 1963; Walker and Tarte, 1963), delayed auditory feedback (King and Wolf, 1965; King and Dodge, 1965), white noise (Berlyne et al., 1965, 1966, McLean, 1968), personality differences (McLean, 1968), drugs (Batten, 1967), and film content (Levonian, 1967).

One of the major purposes of the present investigation was to determine whether the arousal - recall interval interaction phenomenon could be demonstrated when arousal was manipulated through the use of a rapid discrimination task. Those studies (Kleinsmith and Kaplan, 1963; Walker and Tarte, 1963) which first demonstrated the interaction

phenomenon relied on the arousal producing properties inherent in the to-be-remembered stimulus material. The interaction effect was very strong in the Kleinsmith and Kaplan study, but much less so in the second study of the arousal - recall interval phenomenon conducted by Walker and Tarte. With the exception of McLean's (1968) study, a part of which was a replication of the Kleinsmith and Kaplan (1964) study, the effect of arousal on recall was also not so strong in those investigations in which arousal was manipulated experimentally. Batten (1967) reported that his results strongly resembled those of Kleinsmith and Kaplan, but statistically significant differences were not found. Because Batten did not monitor physiological arousal levels, however, as well as the fact that there was a confounding of variables in his study, Batten's findings are inconlusive. This is doubly true as far as the latter criticism is concerned for, not only was there a confounding of the effects on recall of arousal during learning, immediately after learning, and prior to recall, but also a confounding of the effects of drug induced arousal with those of experimentally manipulated arousal.

Other studies of the effects of arousal on immediate and delayed recall in which DAF was the external arousal producing agent presented results which were directionally consistent with predictions from consolidation theory, but in which the effect was not very strong (King and Wolf, 1965; King and Dodge, 1965). Another investigation conducted by Williams and Frinke (1968) in which DAF was employed for arousal purposes failed to produce the arousal recall interval phenomenon in any way. Procedural differences between this investigation and those

conducted by King did not allow for direct comparisons, but it can be said that the findings generally are inconsistent. Since physiological indicants of arousal were not monitored in the Williams and Frinke study, their findings can be considered inconclusive as far as any test of predictions from consolidation theory are concerned.

Berlyne and his associates (1965, 1966) demonstrated the interaction phenomenon using white noise for arousal purposes, as did McLean (1968). Although Berlyne's work warrants the same criticism as that levelled at Batten's and Williams and Frinke's since physiological measures were not employed, its findings are consistent with McLean's wherein the aroual - recall interval interaction was demonstrated using white noise for arousal purposes and monitoring that arousal physiologically. Thus, the criticism of Berlyne's experiments need not be so harsh. Nevertheless, unless physiological indicants of arousal are employed, differences in recall cannot be directly attributed to differences in arousal.

The above criticism of studies in which arousal was experimentally produced, notwithstanding, the general finding, with one exception (Williams and Frinke, 1968), has been that increased arousal at the time of stimulus presentation impairs immediate recall, but enhances delayed recall, whereas the opposite has generally been the case for "no arousal" conditions. To reiterate, one question which was posed by the current study was: Can the arousal - recall interval interaction be demonstrated when arousal is experimentally produced through the administration of the RDT? Crucial to this question is whether or not the RDT can produce the desired increase in arousal. Research carried out by Malmo and his

associates (1951a, 1951b), as well as by Belanger (1957), indicates that the RDT has arousal producing qualities as evidenced in changes in mean arm tension - changes which reflect much more tension than that required to press the response button, changes which were related, not to the motor aspects of the task, but to its psychological difficulty - as well as changes in number of circulating lymphocytes.

In the light of such evidence in support of the arousal producing qualities of the RDT, it seemed reasonable to conclude that the RDT would produce the desired increase in arousal. It should be pointed out that the RDT was modified for use in the current study. The modifications (See p.32), however, were not expected to seriously alter the arousal producing effects which previously obtained with its use. On the contrary, the choice of one-third the number of slide presentations was expected to curtail the previously noted habituation effects. It should also be borne in mind that different indicants of arousal were employed in the present study. Although HR and/or BR changes were not expected merely because EMG and biochemical changes had attended RDT presentation in the past, they were expected if the general concept of arousal proposed by Malmo (1959) were tenable. In order to express this expectation formally, the following hypothesis was proposed:

> Hypothesis I. The RDT will produce a significant increase in arousal as reflected in changes in HR and/or BR.

Assuming that the RDT would produce the desired increase in arousal, it was expected that the arousal - recall interval interaction would obtain in a between condition analysis; that is, those Ss who were exposed to the RDT in one of the treatment conditions were expected to

show impairment of immediate recall, but enhancement of delayed recall, whereas the opposite was expected for the control Ss. In order to express this expectation formally, the following hypothesis was proposed:

> Hypothesis II. Material presented during increased arousal conditions will show poorer immediate recall and stronger delayed recall than material presented under neutral conditions.

The second major question raised in the current investigation was whether the placement of the mediator of arousal at different points in the learning-recall sequence would differentially affect immediate and/or delayed recall. Levonian's (1967) findings suggest that the effects are the same regardless of whether the arousal precedes information presentation or follows immediately thereafter. King and Wolf's (1965) results, on the other hand, suggest that arousal immediately following information presentation enhances delayed recall. Whether the improvement in delayed recall is due to the arousal producing properties of DAF, or due to the fact that competing responses are set into operation with DAF and contribute to the poorer immediate recall, is open to question. In view of the fact that both the DAF group and a control group which received shock showed marked changes in GSR measurements during the crucial middle paragraph, whereas only the DAF group showed an increase in accuracy of delayed recall, it would appear that the alternate explanation is possibly valid. Thus King and Wolf's results did not provide an appropriate guide for predictions in the current study. To return briefly to Levonian's negative results regarding the differential effects of the temporal placement of arousal,

tentative conclusions of some predictive value could be drawn; for example, increased arousal will not differentially affect immediate and delayed recall when it precedes or follows immediately after the presentation of to-be-remembered material. Berlyne and his associates (1966) had produced results which also pointed to such a prediction, although they did state that "the effects of arousal immediately after learning are variable and complicated".

Unfortunately, direct parallels could not be drawn between these two studies in which arousal was manipulated in a relatively indirect manner (film material or white noise) and the present investigation in which arousal was produced through the administration of the RDT - a task requiring the S's attention immediately before or after the presentation of the to-be-remembered material or immediately before recall. Because of the nature of the task, and the very fact that it was a task and not an incidental arousal producing agent, predictions of the variety of the one stated above did not seem to be reasonable. Rather, it was expected that, because of the possible disruption of the consolidating process during RDT when the task came immediately after story presentation, this group would show poorer immediate and delayed recall than would the groups having the RDT presented before the story, before recall, or not at all. In order to formally express this expectation, the following hypothesis was proposed:

> Hypothesis III. Material whose presentation is immediately followed by increased arousal conditions will show poorer immediate and delayed recall than material preceded by increased arousal conditions, material whose recall is preceded by increased arousal conditions, or material presented under neutral conditions.

The implications of Bourne's study which showed that increased tension prior to recall enhanced recall (See p. 27) suggested another expectation regarding differences in recall with variations in the temporal placement of the mediator of arousal; viz., that the group to whom the RDT was to be presented immediately before recall would show better immediate and delayed recall than the control or other treatment groups. In order to express this expectation formally, the following hypothesis was proposed:

> Hypothesis IV. Material whose recall is immediately preceded by increased arousal conditions will show better immediate and delayed recall than material preceded, or followed by increased arousal conditions, or material presented under neutral conditions.

The above stated hypotheses were formalized so that tests could be made and possibly answers provided to the two major questions raised by the current study: (1) Can the interaction between arousal and recall interval be demonstrated when arousal is experimentally produced through the administration of the RDT? (2) Does the placement of the mediator of arousal at different points in the learning-recall sequence differentially affect immediate and/or delayed recall? Neither of these questions, however, lead to the generation of an hypothesis to parallel the general experimental hypothesis which tests consolidation theory, that is, the hypothesis which states that an increase in arousal during presentation of to-be-remembered material will produce more intense trace activity, thereby making the material less available for immediate recall while consolidating it for improved delayed recall.

With but one exception, the pertinent literature surveyed supported

this general hypothesis. The reported effects were especially strong in those studies in which either stimuli or Ss were ordered into "high" or "low" conditions on the basis of physiological reactivity during the actual presentation of the stimulus material. In view of the positive results of such a procedure, as well as the fact that it allows for valid assumptions regarding the relationship between arousal and recall, it seemed wise to include this approach in the current study. Although methodological differences between those studies cited in support of the "consolidation hypothesis" and the present investigation are many, it was assumed that, if the interaction between arousal and recall interval were a generalizable phenomenon (and the breadth and variety of the related research surveyed suggested that this was the case), the phenomenon would occur in the present study. In other words, it was expected that those Ss who showed "high arousal" (marked changes in HR and/or BR) during the story presentation would produce poorer immediate recalls, but better delayed recalls than would the "low arousal" group (those Ss who showed little or no change in HR and/or BR during story presentation. In order to express this expectation formally, the following hypothesis was proposed:

> Hypothesis V. Material presented during "high" arousal will show poorer immediate recall and stronger delayed recall than material presented during "low" arousal.

These five hypotheses reflect the major predictions generated by the theoretical and empirical literature herein considered. It should be recalled, however, that ancillary expectations related to the phenomenological aspects of the current study were also proposed (See p. 36). Briefly restated those expectations were as follows:

(1) Those Ss who show cardiac deceleration (decrease in HR) will recollect that they felt more accepting during the experiment than those Ss who show cardiac acceleration (increase in HR) who will recollect that they felt more rejecting.

(2) Those Ss exposed to the RDT during the experiment will recollect that they felt less comprehending than will the controls.

(3) Those Ss exposed to the RDT will recollect that they felt more aroused than will the controls.

(4) Those Ss who recollect that they felt more accepting during the experiment will show better recall than those Ss who recollect that they felt more rejecting.

(5) Those Ss who are ordered into the "high" arousal condition on the basis of HR and/or BR changes at the time of story presentation will recollect that they felt more aroused than will those Ss who are ordered into the "low" arousal condition.

CHAPTER II

METHODOLOGY AND PROCEDURE

Subjects

The Ss employed in this study were 28 undergraduate students enrolled in the Extension Division of the University of Windsor. The age range of the Ss was from 19 to 29 years, with a mean age of 22.71. The sample was comprised of 16 females and 12 males.

Each of the 16 females was randomly assigned to one of the following four conditions: (1) control, (2) arousal prestory, (3) arousal post-story, (4) arousal pre-recall. The males were likewise assigned so that there were 4 females and 3 males in each treatment group. A total of 31 Ss had participated in the experiment, but data from 3 Ss had to be discarded because of apparatus failure in one case and complete misunderstanding of instructions in two others.

All Ss were naive as to the nature of the experiment and had no previous experience in the physiological laboratory. They were not reimbursed for participating in the experiment and were free to refuse when contacted one day in advance of the experimental session. They were, however, requested to return on the day following the initial session.

Apparatus

A standard Offner eight-channel, ink-recording TYPE R DYNOGRAPH was employed to measure, amplify, and record the physiological indicants

of arousal. Channels 2 and 6 were used, the former to record HR and the latter, BR. Each of these channels was functionally comprised of an input selector, input coupler, pre-amplifier, amplifier, zero setting control, and an ink-recording unit. The couplers were specific to the task; i.e., a Carditachometer Coupler (Type 9851) was used to record HR and a Strain Gage Coupler (Type 9803) was used to record BR.

In addition to the eight ink-recording units, the Dynograph was equipped with two event-marker pens. One of these was employed to record the S's responses to the RDT; the other recorded the experimenter's (E's) presentation of a tone when an incorrect response to a RDT slide was made by the S. The onset and offset of each slide in the RDT was also recorded. Channel 8 was used for this purpose with a standard Type 4818 preamplifier as the input coupler employed. An example of recordings made by each of the ink-recording units of the 3 channels employed, as well as those made by the event-marker pens, is presented in Figure 1.

Offner Type 350069 surface electrodes were used to monitor HR, and an Offner Type 7001 Respiration Transducer, to gauge BR. Beckman, Offner electrode paste was the conduction medium employed. A Bausch and Lomb "Balomatic" 500 slide projector was used to present the RDT slides. Hunter timers in conjunction with the "semi-automatic" triggering device of the projector were utilized to control slide presentation time. The timing was within 1/30 second as recorded by the responses of a photo-electric cell which was mounted on the top of the slide projector in a position which allowed it to pick up the light reflectance from the two-way mirror through which the light travelled

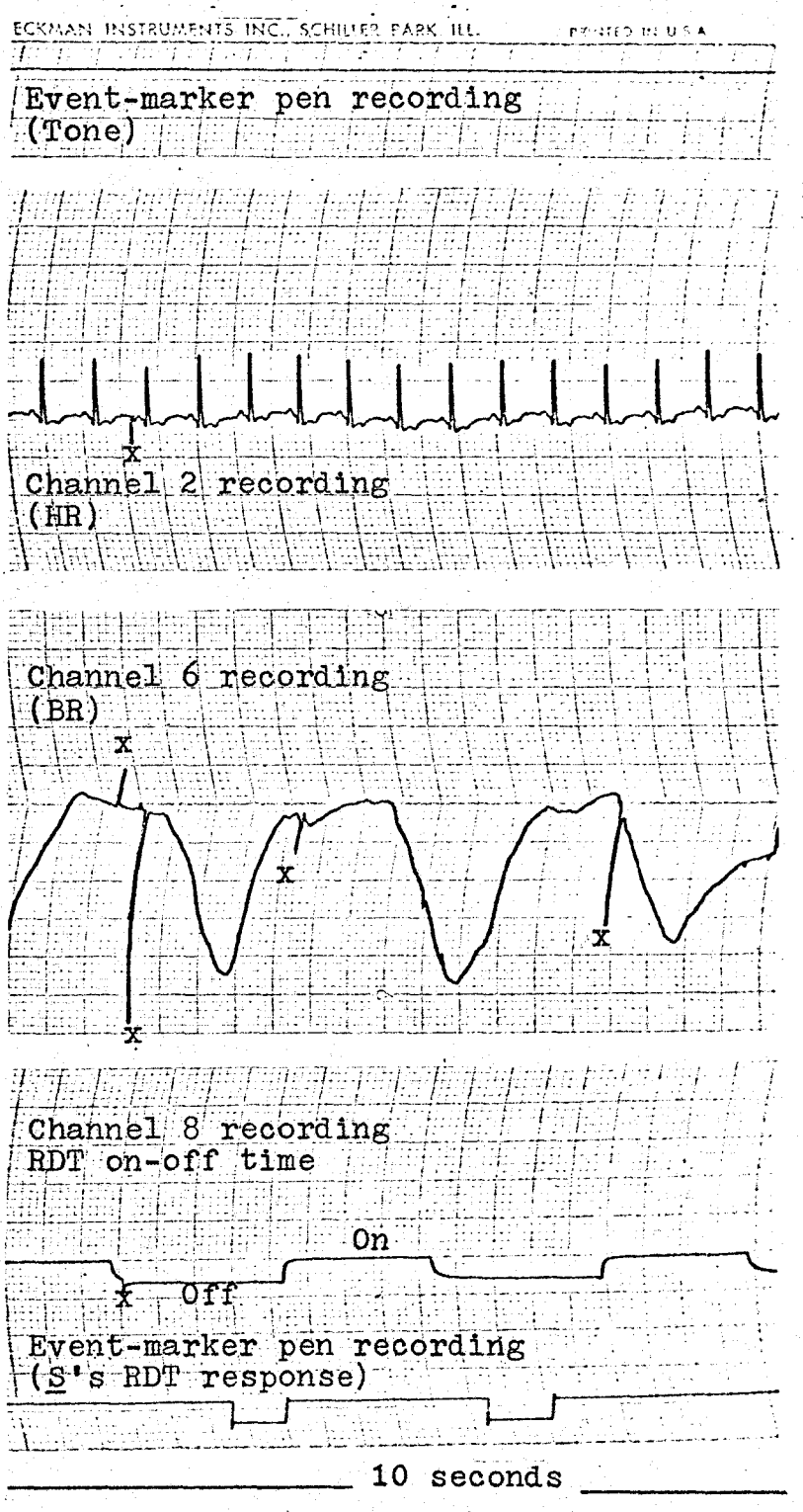

Figure 1. An example of physiological and event recordings made by the dynograph. "x" indicates switching artifact.

during slide presentation. As mentioned above, channel 8 of the dynograph was used to amplify and record the photo-electric cell's responses.

A six-button response panel whose circuitry made connections with a six-light response console as well as with the Dynograph recorder had been constructed to specification for the purposes of the current study. The circuitry of this apparatus was such that a depressing of response button 1 would automatically activate response light 1 and trigger a deflection in the event-marker pen recording of the S's response. Response button 2 was connected with response light 2, button 3, with light 3, and so on. In addition to the six response lights on the response console, there was a button which on depressing would activate an RCA Audio-generator and Amplifier to produce a clearly audible, but nonnoxious tone at a frequency of 1000 Hertz (Hz.). Depressing this tone button also triggered a deflection in the event-marker pen recording of tone presentation. Standard laboratory earphones were used to deliver the tone. To preclude an unnecessary encumbrance of the S, the earphones were hung on a rack directly beside the S's head.

A twelve-volt standard automobile battery provided direct electrical current to power the response panel and console as well as the audio-generator and amplifier. Additional apparatus used in the experiment included a standard plug board, a chair and two tables. The plug board, situated on the back of the S's chair, allowed for connections between the electrodes and the dynograph. A direct connection was made from the Respiration Transducer to the dynograph. The S's chair was a standard laboratory armchair (wooden) with a cushion covering the back and seat as an aid to comfort. The two tables, one on which the S rested his arms, the other on which

were situated the slide projector, response console, and audio-generator and amplifier, completed the apparatus. A schematic diagram of the apparatus which depicts its approximate physical arrangement appears in Figure 2.

Materials

The material for the RDT consisted of 30 slides which were produced by photographing (5 times) 6 stimulus cards. For illustrative purposes, one of the stimulus cards is reproduced in Figure 3 showing the actual size of the circles - 11/16 inch in radius with the exception of the larger circle (2) which has a radius of 23/32 inch. On each of the other 5 cards the larger circle appeared in a different position. The slides were identified by the number of the larger circle. Using a table of random numbers, the order of presentation of the slides, which appears in Appendix A, was determined. A restriction factor was applied to the randomization process: slides with the larger circle in the same position were not allowed to appear in succession.

A typed copy of the story, "The War of the Ghosts", as shown in Appendix B was encased in a clear plastic folder for presentation. This version of the story is essentially that used by Bartlett (1932), although it incorporates some minor changes made by Papageorgis and Tyler (1966). Lined manuscript paper and pens were provided for the writing of recalls.

McCarter's (1961) Recollection Rating Scale (RRS) was adapted for use at both immediate and delayed recall. The modified version of the RRS as it was presented to the S appears in Appendix C.

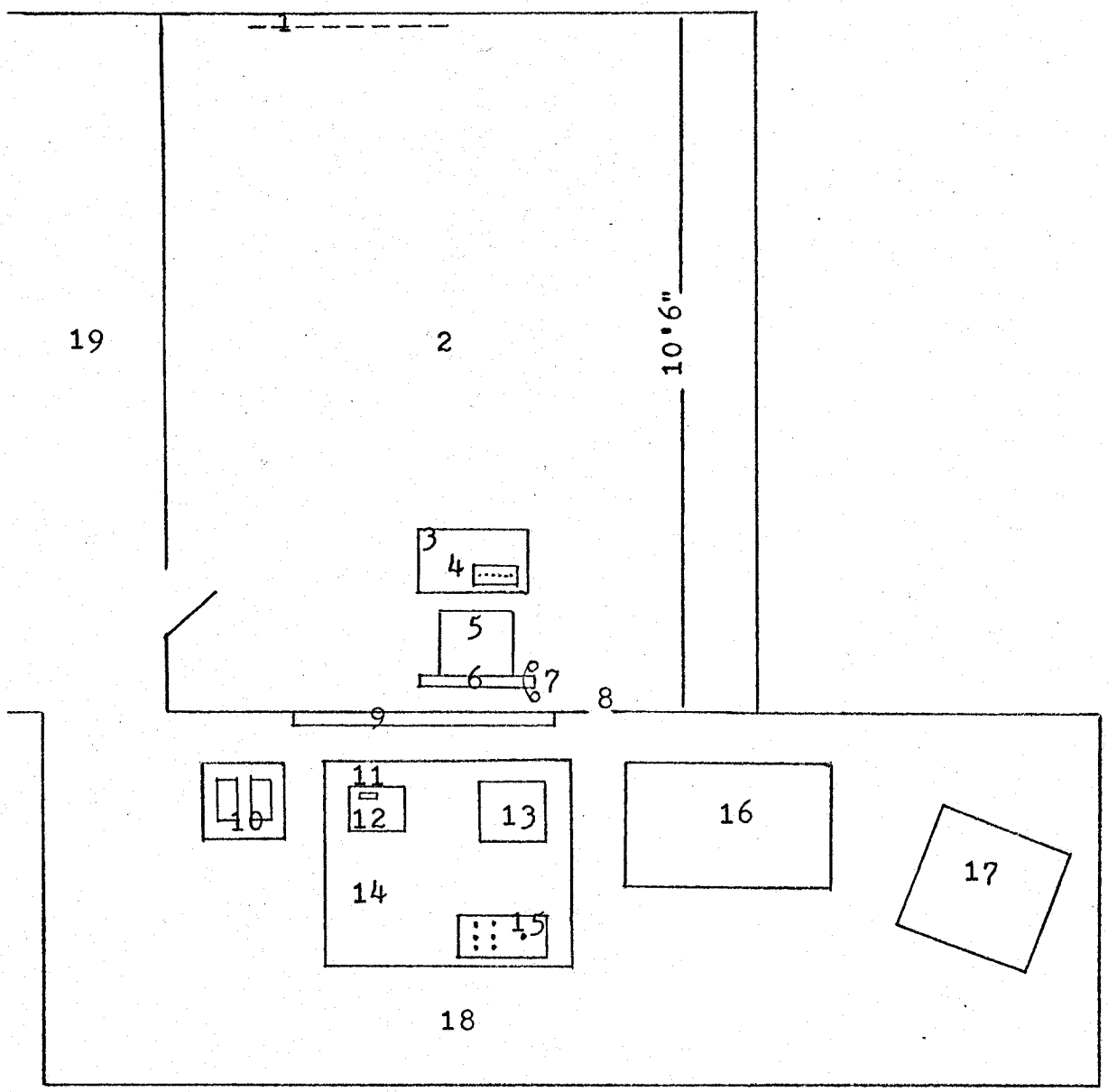

Figure 2. Schematic diagram of the physical arrangement of the experimental apparatus. (Not drawn to scale)

1. Wall area used as screen
2. Experimental room
3. Table
4. Response panel
5. Armchair
6. Plug board
7. Earphones
8. Lead porthole
9. Two-way mirror
10. Hunter timers
11. Photo-electric cell
12. Slide projector
13. Audio-generator and amplifier
14. Table
15. Response console
16. Dynograph recorder
17. Dynograph console
18. Control room
19. Preparation room

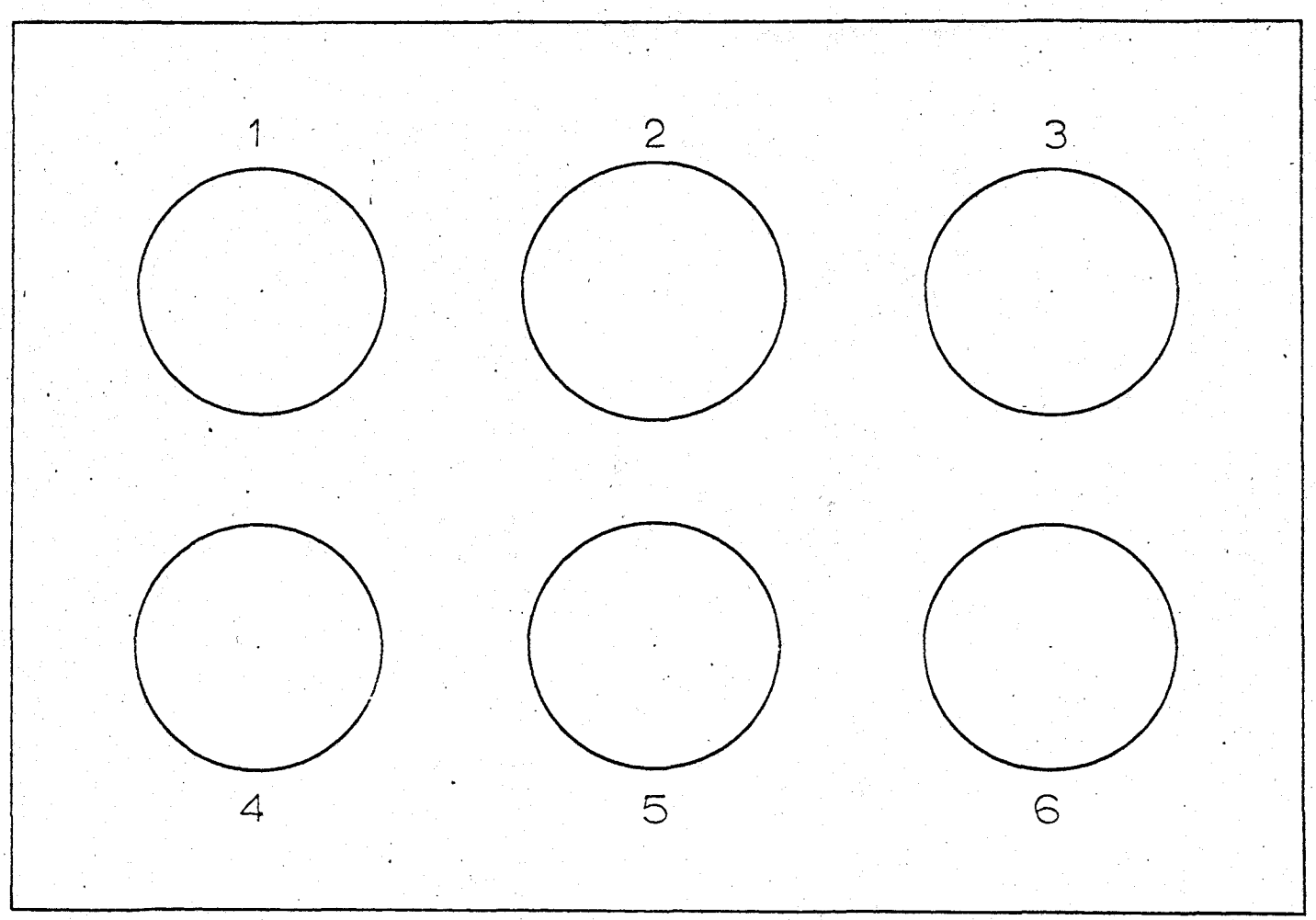

Figure 3. One of the stimulus cards which was photographed for RDT slide production. Circles are actual size.

Procedure

All Ss were run individually in the afternoon hours during the month of August. The laboratory complex in which the experiment was conducted had thermostat controlled air conditioning. The thermostat was set at 70 degree Fahrenheit and remained at that setting for the duration of the experiment. All Ss appeared either on time or a few minutes ahead of schedule. If the latter were the case, a sign outside the laboratory indicated that experimentation was ongoing at that moment, but that the S was to be seated until his scheduled appointment time. At the appointed hour (12:00, 1:30, 3:00 or 4:30) the S was greeted and ushered into the preparation room. There the S was prepared for the physiological recording by cleansing with "Phisohex" and then swabbing with rubbing alcohol the radial region of the left wrist (right, if S were left-handed), the junction of the medial and outer two-thirds of the left forearm (right, if S were left-handed), and a lateral area of the lower right leg (left, if S were left-handed). Using Offner electrode paste, the electrodes were applied to the cleansed areas and secured with adhesive collars. During this preparation period the following information was conveyed to the S:

> I am conducting a physiological study as my doctoral research. The purpose of this research is the determination of any differences in physiological responses which occur when an individual is involved in different activities. The responses that I am interested in are HR and BR. In order to record HR it is necessary to apply these electrodes which will pick up your heart beat. They are very sensitive electrodes, so sensitive that they need not be applied to the chest region, but rather will pick up your heart beat when they are applied to your arm and leg. In order to ensure clear recording, however, it is necessary to cleanse your skin where the electrodes are going to placed.
>
> The basic principle underlying electrophysiological recording is very straightforward. Your muscles are activated by electrochemical processes which originate in your brain and are conducted by neurons to your muscles. Your heart is like a very large muscle, and the

> electrical activity involved in its beating will be picked up by these electrodes.
>
> To measure your breathing I will be putting a strain gauge on you when we go into the recording room. It is like a belt which expands and contracts as you breath in and out.

When the electrodes had been applied, the S was ushered into the experimental room and comfortably seated. Here the Respiration Transducer was attached to the S (See Figure 4) and connections made from the electrodes to the plug board. The S was then asked to relax while E made adjustments on the recording equipment. This "adjustment" period was of approximately seven minutes duration. During the first two or three minutes there was some verbal communication between E and S; for example, E requested S to take a deep breath in order to ascertain the direction of inhalation and expiration on the BR recording. As soon as the necessary adjustments were made to the Strain Gauge and Cardiotachometer Couplers, the recording rate was set at 10 millimeters per second. This marked the beginning of the experiment proper. HR and BR measures recorded during the last 10 seconds of the fourth minute of the experimental period became the initial basal readings.

Since the timing of information input; i.e., the presentation of the story, as well as the timing of the arousal producing task (RDT), was crucial to the experiment, procedural variations which occurred in each of the four conditions can be best conceptualized within a temporal framework. Figure 5 is a schematic representation of the relationship between arousal input and information input over time for the four groups. Inspection of Figure 5 shows that all Ss, regardless of condition, were presented with the story at 7.5 minutes and asked for recalls at 17.5 minutes. Instructions accompanying the presentation of the story were:

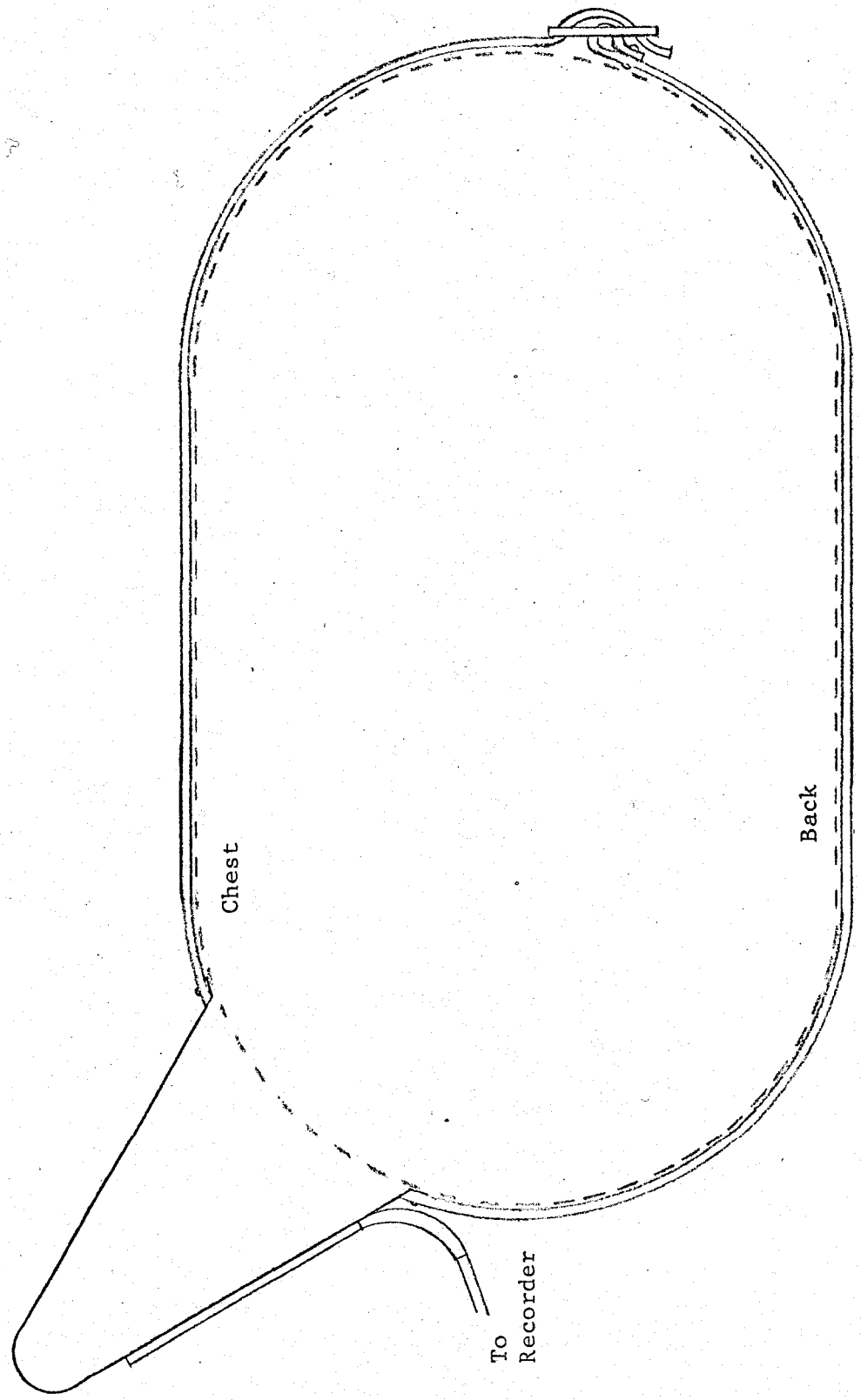

Figure 4. Attachment of the Respiration Transducer to S.

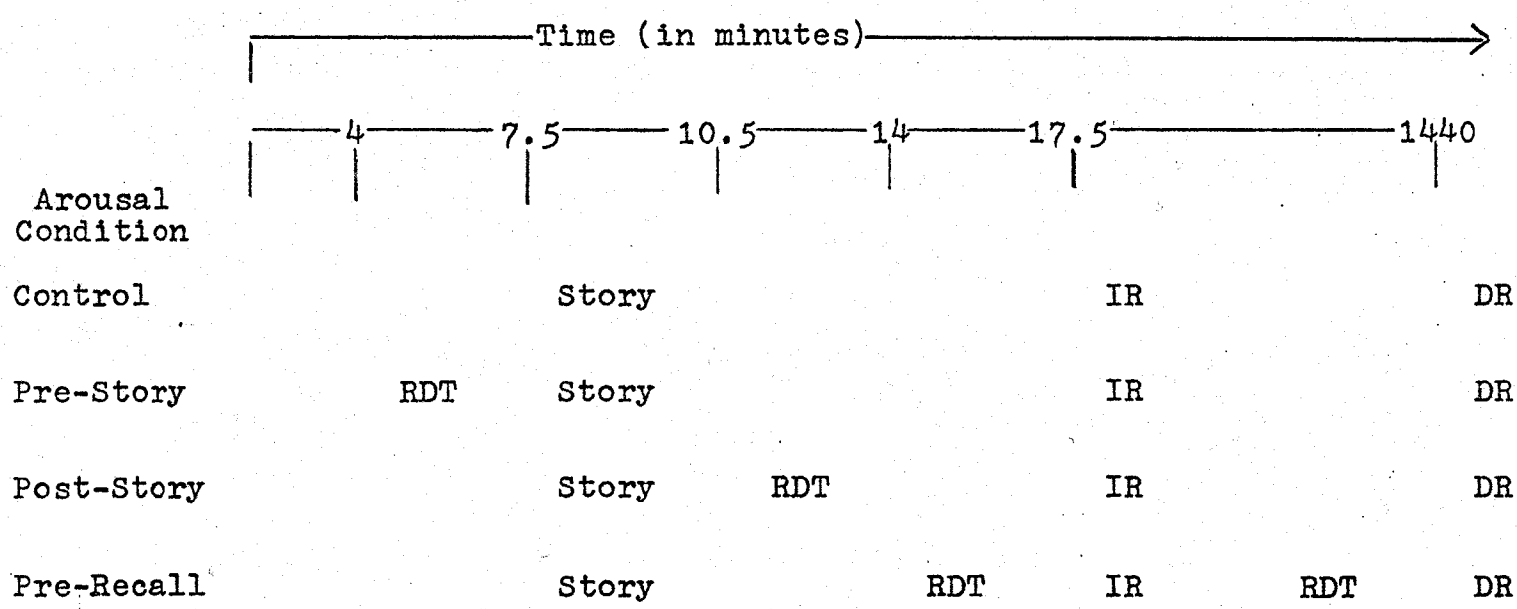

Figure 5. Schematic representation of the temporal relationships between arousal input (RDT), information input (Story), and immediate (IR) and delayed (DR) recall intervals.

> I would like you to read this story, carefully, twice. When you have finished reading it the second time, please press this button (response button 1 on the panel in front of the S was indicated).

The E then returned to the control room. When the event-marker pen recording S's reponses showed a deflection, E immediately returned to the experimental room to retrieve the story. E picked up the story with a "thank you" and immediately returned to the control room unless the S was in the Arousal Post-Story condition. If the latter were the case, the S would be immediately presented with the instructions for the RDT which were as follows:

> Your task in this part of the experiment is to judge the size of circles. On this wall (wall which S was facing was indicated) will be projected slides like this one (one of the stimulus cards like that shown in Figure 3 was briefly presented) with six circles. On each slide, one of the circles is slightly larger than the other five. Your task is to decide which circle is larger and indicate your choice by pressing the appropriate button here (response panel was indicated).
>
> Please note that the circles on the slides will appear in two rows like this (stimulus card was again briefly presented), whereas the response buttons on your panel are in one row. Remember, your task is to choose the larger circle and press the appropriate button. Do you have any questions?

Any questions asked by S were answered by reiterating that portion of the instructions pertaining to the question. The experimental room was then darkened and the slide projector activated to present the slides in the order shown in Appendix A. Exposure time of each slide was 2.00 seconds; slide exchange time was 2.30 seconds. Allowing time for instructions, approximately 3.50 minutes were required for RDT presentation.

The Ss in the Pre-Story condition received instructions and RDT presentation in the period between the end of the initial basal period of 4 minutes and the presentation of the story at 7.5 minutes. Pre-Recall Ss were presented with the RDT at 14 minutes; i.e., immediately before immed-

iat recall. To this group the RDT was also presented immediately before recall on the following day.

Instructions presented to all Ss at 17.5 minutes which marked the beginning of immediate recall (IR) were:

> Your task now is to reproduce, as completely and as accurately as possible the, story which you read.

Lined manuscript paper and two pens were placed on the S's table and a response button was indicated as the following additional instructional statement was made:

> Please press the button to signal when you have finished writing the story.

When the event-marker pen recording of S's response signalled completion, E returned to the experimental room, collected the story reproduction, and asked S to complete the RRS. When S indicated his completion of the RRS, E returned and stated:

Thank you. Please relax now while I take some further recordings.

Four minutes later dynograph switches were turned to "off" positions and E entered the experimental room, disconnected the electrodes, removed the strain gauge, and then ushered S into the preparation room. There the electrodes were carefully removed and the skin cleansed and swabbed with alcohol. The S was thanked for participating and the following request was made:

> My experiment requires that further recordings be taken the day following the first part of the experiment. I would appreciate it very much if you could return tomorrow at ___ o'clock. The recording session tomorrow will take less than half an hour.

On the S's return the following day, he was taken immediately into the experimental room, asked to be seated, and the Respiration Transducer was attached. Then the following statements were made by E:

> Today, I shall just be taking breathing measures. Please relax now while I make some adjustments to the recorder.

As soon as the necessary adjustments were made to the Strain Gauge Coupler, the recording rate was set at 10 millimeters per second. This marked the beginning of a four-minute basal period. At the end of that time, E entered the experimental room and announced the following:

> Your task today is to reproduce, as completely and as accurately as possible, the story which you read while you were here yesterday.

Paper and pens were again provided and the S requested to signal his completion by pressing one of the response buttons. Then the S was asked to complete the RRS with the reminder that he was to rate the feelings which he had during the experiment on the previous day. A four-minute post-experimental period followed, after which the Respiration Transducer was removed. The S was again thanked for his participation and cautioned against discussing the nature of the research with fellow students.

Scoring Procedures

Recall Scoring

The 56 reproductions (recalls) of "The War of the Ghosts" were scored by E, as well as by a colleague, by each of the following four methods: content words (CW), words produced (WP), words to maximum (WM), and words scored once (WO).

Content words. By this scoring procedure, as used by King (1960), all articles, conjunctions and prepositions were eliminated from the original story (See Appendix D) and the recalls checked to determine the presence of the remaining content words. To be scored in the recall, the word had to be exactly as presented in the original except for minor spelling variations. No penalty was awarded for words being out of sequence or for the

presence of words not in the original story. There was no limit to the number of times that a recalled word was counted; for example, a recall might have had the word, "ghosts", present four times, whereas the original story used the word only three times, yet credit was given for four.

Words produced. This score was arrived at by simply counting the number of words that the S used in writing his reproduction.

Words to maximum. Content words, as defined above, were scored within the limit of their frequency in the original story.

Words scored once. Content words used in the recall were scored once only regardless of their frequency in the original story or reproduction.

Scoring of Physiological Responses

Samples, 10 seconds in duration, of each S's record were drawn from the following points: termination of the initial four-minute basal period; commencement, mid-point, and termination of the story reading; commencement, mid-point, and termination of RDT; commencement, mid-point, and termination of IR; and termination of the four-minute post-experimental period. Thus, 11 samples were taken from the record of each S in the three treatment groups. From the records of control Ss, however, 17 samples were required. This was due to the fact that these Ss served as controls for each of the treatment groups, and therefore 9, rather than 3, samples were needed from the periods which corresponded in time with RDT presentation to the treatment groups.

A 10-second sample taken from S_{15}'s record, as shown in Figure 6, will serve to demonstrate the scoring procedure employed. The sample shown fell within the 10-second interval immediately following the mid-point in RDT presentation. Thus, along with the recording of S's heart beat in Channel

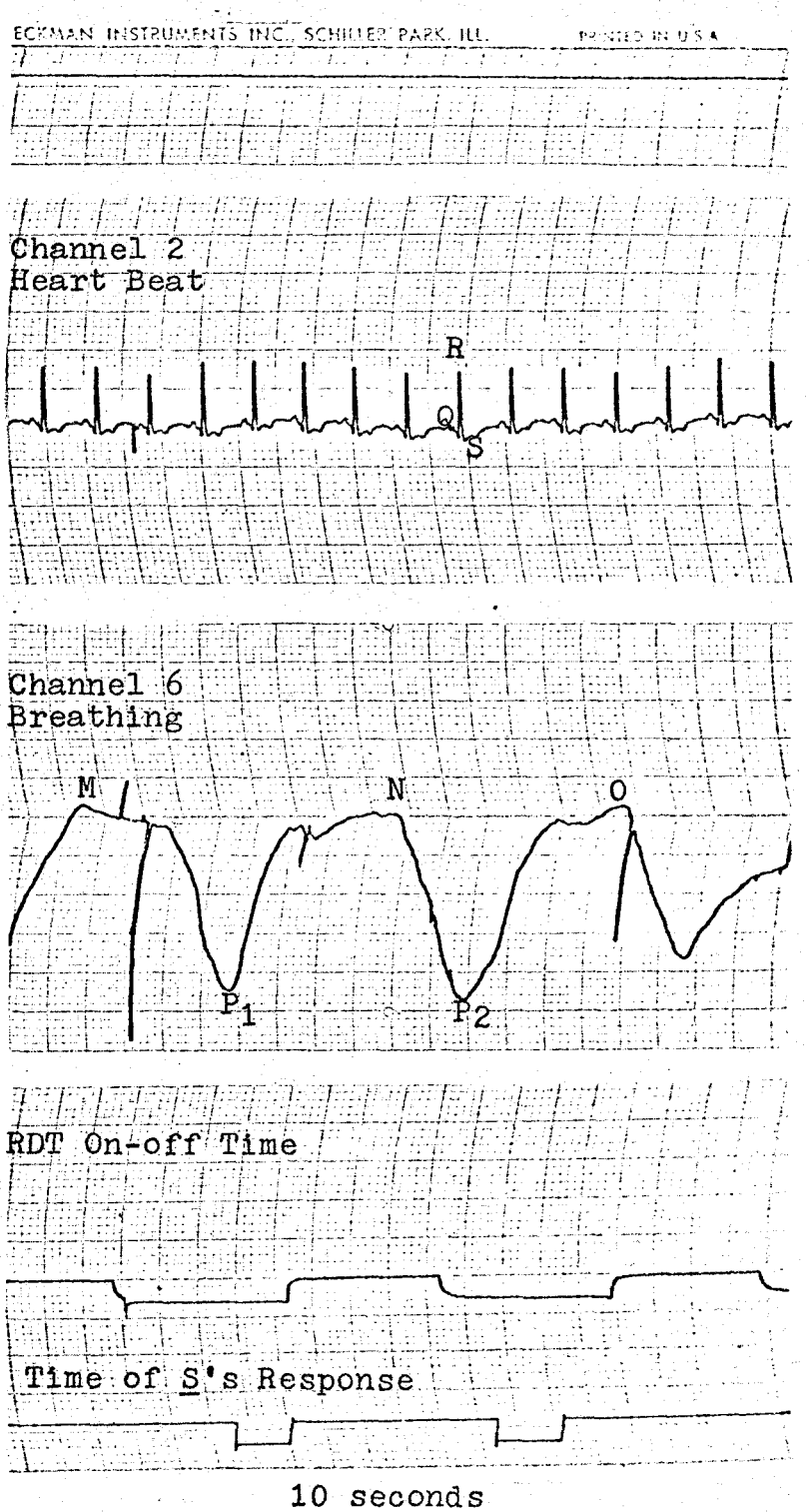

Figure 6. Sample from S_{15}'s record used to demonstrate scoring procedure.

2 and breathing in Channel 6, there appears the RDT slides on and off recorded times, as well as the S's time of response to those slides. The actual calculations used to arrive at HR and breathing scores are outlined below.

Scoring of HR

The QRS wave (See Figure 6) represents one beat of the S's heart. To facilitate scoring, however, the Rs (peaks) only were counted. Since the recording speed was 10 millimetres per second, the total number of Rs in the sampled 10-second period was multipled by 6 to arrive at the HR score which is a measure of the number of times the heart beat per minute. S_{15}'s heart beat 14 times in the sampled 10-second interval. When this value was multiplied by 6, a HR recording of 84 resulted.

Scoring of Breathing Measures

To establish reliable breathing scores, at least two complete inspiration-exhalation cycles were measured. In Figure 6 the first breathing cycle is labelled M - P_1 - N, and the second, N - P_2 - O. The distance, 41 millimetres, between M and N represents the time required for one complete breathing cycle; the distance, 31 millimetres, between N and O represents the time required to complete the subsequent breathing cycle. At the recording rate of 10 millimetres per second, the total distance between M and O (72 millimetres) represents 7.2 seconds. In order to arrive at a breathing rate (BR) in terms of number of complete cycles per minute, 60 was divided by 7.2 and multiplied by 2. These calculations resulted in a BR score of 16.67 which indicates

that the S was breathing at the rate of 16.67 cycles per minute.

In addition to BR, amplitude measures were also taken. With reference to Figure 6 again, the depth of breathing during the first sampled cycle (M - N) is represented by M - P_1 which is the maximum linear displacement of the recording pen produced by inhalation. In the second cycle the amplitude is represented by N - P_2. Taken to the nearest millimetre, these displacements were measured at 24 millimetres each. Thus, the amplitude or depth of breathing (DB) measure at this point in S_{15}'s record was 24. Displacement measures were not always the same, however, for the two or more cycles measured in any sample. Thus, the mean DB value of the two or more cycles in the sample became the DB score for that sample.

CHAPTER III

PRESENTATION AND ANALYSES OF RESULTS

The experimental results which are concerned with the arousal producing properties of the RDT (Hypothesis I) are presented first, followed by those which pertain to the predicted interaction between arousal condition and recall interval (Hypothesis II), and those related to expectations regarding the effects of time of arousal on recall (Hypotheses III and IV). In the fourth section are results pertaining to the predicted interaction between arousal level and recall interval (Hypothesis V). Each of these four sections is followed by a short summary of the results therein contained. In the fifth section are presented the phenomenological findings, followed by a section devoted to additional relevant results.

Hypothesis I

It was hypothesized (Hypothesis I) that the RDT would produce a significant increase in arousal as reflected in changes in HR and/or BR. Before analyses which test this hypothesis could be presented, however, it was first necessary to determine for each S basal rates from which changes in HR and/or BR could be measured. The means of measures taken during the initial four-minute basal period and those taken during the four-minute post-experimental period were considered appropriate measures to use as bases since they controlled for minor variations in physiological responses over time. Significant differences

in those variations, however, would preclude their use as reliable basal scores. Therefore, the basal readings, which appear in Appendix E, were subjected to analyses. The first of these analyses, a two-way analysis of variance with arousal condition and time as the main effects was carried out for the HR basal readings. As presented in Table 1, the summary of this analysis indicates that the F ratios for the main effects were not significant. Nor was the interaction term significant. Thus, it could be safely assumed that the groups did not differ in HR during the basal periods, and secondly, that HR did not differ significantly from initial to terminal basal readings.

Table 1

Two-Way Analysis of Variance of HR Basal Measures With Arousal and Time as Main Effects

Source	df	Mean Square	F Ratio
Arousal (A)	3	460.21	1.45
Error (a)	24	317.86	
Time (T)	1	27.16	1.21
AT	3	35.64	1.59
Error (t)	24	22.43	

A two-way analysis of variance with arousal condition and time as the main effects was also carried out for the BR basal readings. A summary of this analysis appears in Table 2. The F ratios for arousal and the interaction were not significant, but the F ratio for time was significant at the 0.05 level indicating that BR measures differed

significantly from the initial to the terminal base periods.

Table 2

Two-Way Analysis of Variance of BR Basal Measures With Arousal and Time as Main Effects

Source	df	Mean Square	F Ratio
Arousal (A)	3	61.62	1.60
Error (a)	24	38.54	
Time (T)	1	26.80	4.46*
AT	3	3.01	0.50
Error (t)	24	6.01	

* $F_{.95}(1,24) = 4.26$

Having established that there were no significant differences between the initial and terminal HR basal readings, a mean of these two measures was calculted for each S and designated his basal HR. These means appear in Appendix F. Because BR was found to differ significantly from the initial to the terminal basal readings, means were not calculated, and BR measures per se were not subjected to any further analyses.

Additional breathing measures, viz., depth of breathing (DB), were made at each point in the records where BR and HR samples had been taken. These DB measures, when multiplied by corresponding BR measures, produced approximate volume measures, i.e., BR x DB was a measure of the amount of air inhaled and exhaled per minute. As a prerequisite to the establishment of mean BR x DB basal measures, a two-way analysis of

variance with arousal and time as the main effects was carried out for the BR x DB measures resulting from the initial and terminal BRs and DBs. A summary of this analysis appears in Table 3. None of the F ratios was significant which indicates that BR x DB values did not vary significantly across the arousal groups or the basal reading times.

Having established that BR x DBs calculated from the initial basal period did not differ significantly from those calculated from the terminal basal period, means of these two measures were calculated for all Ss and designated basal BR x DB values. These means appear in Appendix F.

Table 3

Two-Way Analysis of Variance of BR x DB Basal Measures With Arousal and Time as Main Effects

Source	df	Mean Square	F Ratio
Arousal (A)	3	13,620.30	0.64
Error (a)	24	21,367.43	
Time (T)	1	61.89	0.03
AT	3	435.84	0.23
Error (t)	24	1,910.74	

Arousal During RDT

Absolute changes from mean HR and BR x DB scores were calculated for each S from the raw data which appears in Appendix E. Treatment group mean change in HR, as well as changes calculated for the control group at the three different temporal points, are presented graphically

in Figure 7. The control group manifested the least change in HR, although there were variations in absolute change from base across the three recording points as well as during each temporal interval. The fact that such changes in HR were shown by the control group indicates that the experimental situation, without the presentation of RDT was in part arousing. On the whole, however, the experimental groups showed greater HR changes, although changes at the beginning of RDT presentation for the Pre-Story and Post-Story groups are not markedly different from those for Controls 2 and 3. Changes at the mid-point and end of the RDT presentation, however, vary considerably. The Pre-Recall group showed the greatest HR change although the pattern across the three recording points is very similar to that manifested by the Post-Story group.

To determine whether the differences in HR changes noted in Figure 7 were statistically significant, four analyses of variance were carried out for HR changes during RDT presentation. The first of these analyses, a summary of which appears in Table 4, is a two-way analysis of variance

Table 4

Two-Way Analysis of Variance of HR Changes During RDT With Treatment$_1$ and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	1	106.88	2.40
Error (tr)	12	44.55	
Time (T)	2	13.16	2.18
Tr x T	2	2.60	0.43
Error (t)	24	6.05	

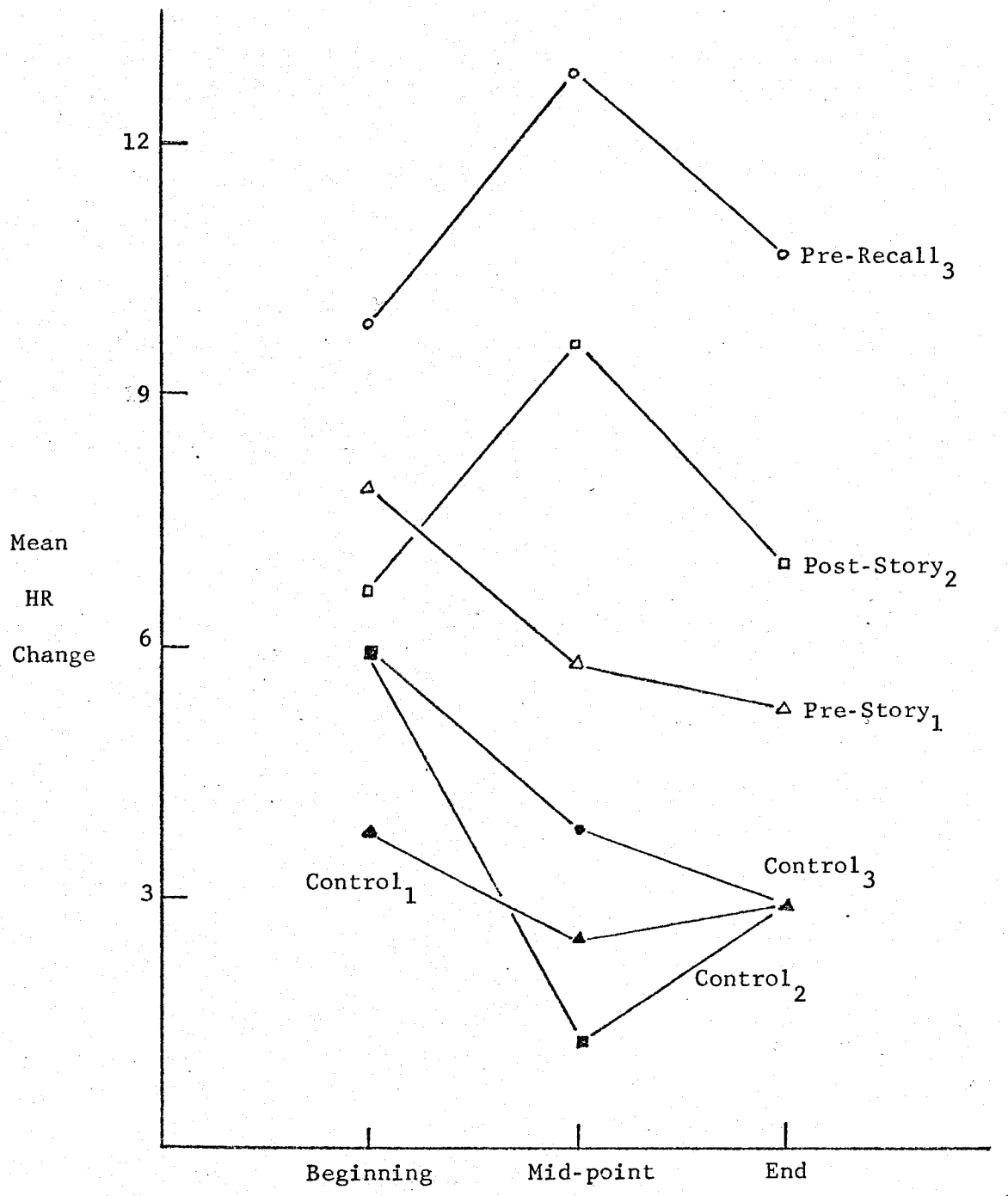

Figure 7. Mean absolute change in HR during RDT presentation.

with treatment$_1$ and time as main effects. The F ratios were not significant indicating that HR changes did not vary significantly between the Control and Pre-Story groups nor over time during the presentation of RDT. Hypothesis I, which predicted a significant increase in arousal as reflected in HR changes during RDT presentation, was therefore not upheld in this case.

Another two-way analysis of variance with treatment$_2$ and time as the main effects was performed for the HR changes during RDT. A summary of this analysis, which is presented in Table 5, presents a significant ($p = 0.05$) F ratio for treatment. This statistical finding indicates that HR changes in the Post-Story group were significantly greater than those in the Control group. Thus Hypothesis I was upheld in this case. In other words, the RDT will produce a significant increase in arousal as reflected in absolute change in HR, when it is presented immediately after the story.

Table 5

Two-Way Analysis of Variance of HR Changes During RDT With Treatment$_2$ and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	1	197.17	9.09*
Error (tr)	12	21.69	
Time (T)	2	6.74	0.33
Tr x T	2	50.45	2.45
Error (t)	24	20.60	

* $F_{.95}(1,12) = 4.75$

The third two-way analysis of variance which was carried out for HR changes during RDT presentation time had $treatment_3$ and time as main effects. The summary of this analysis, presented in Table 6, shows no statistically significant findings as far as HR changes, which occurred during RDT presentation to the Pre-Recall group, when compared with those changes in HR occurring at the same time in the Control group. Thus Hypothesis I was not upheld in this case.

Table 6

Two-Way Analysis of Variance of HR Changes During RDT With $Treatment_3$ and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	1	493.71	3.17
Error (tr)	12	155.57	
Time (T)	2	8.36	0.52
Tr x T	2	25.08	1.57
Error (t)	24	15.96	

Mean absolute BR x DB changes shown by the three treatment groups and the Control group at the three recording intervals during the presentation of RDT are presented graphically in Figure 8. As was the case with HR changes during RDT, BR x DB changes for the Control group were smaller than those for the treatment groups. For the Controls, however, there were variations in mean absolute change in BR x DB scores across the three recording intervals. On the whole, the treatment groups demonstrated somewhat similar variation, although at higher

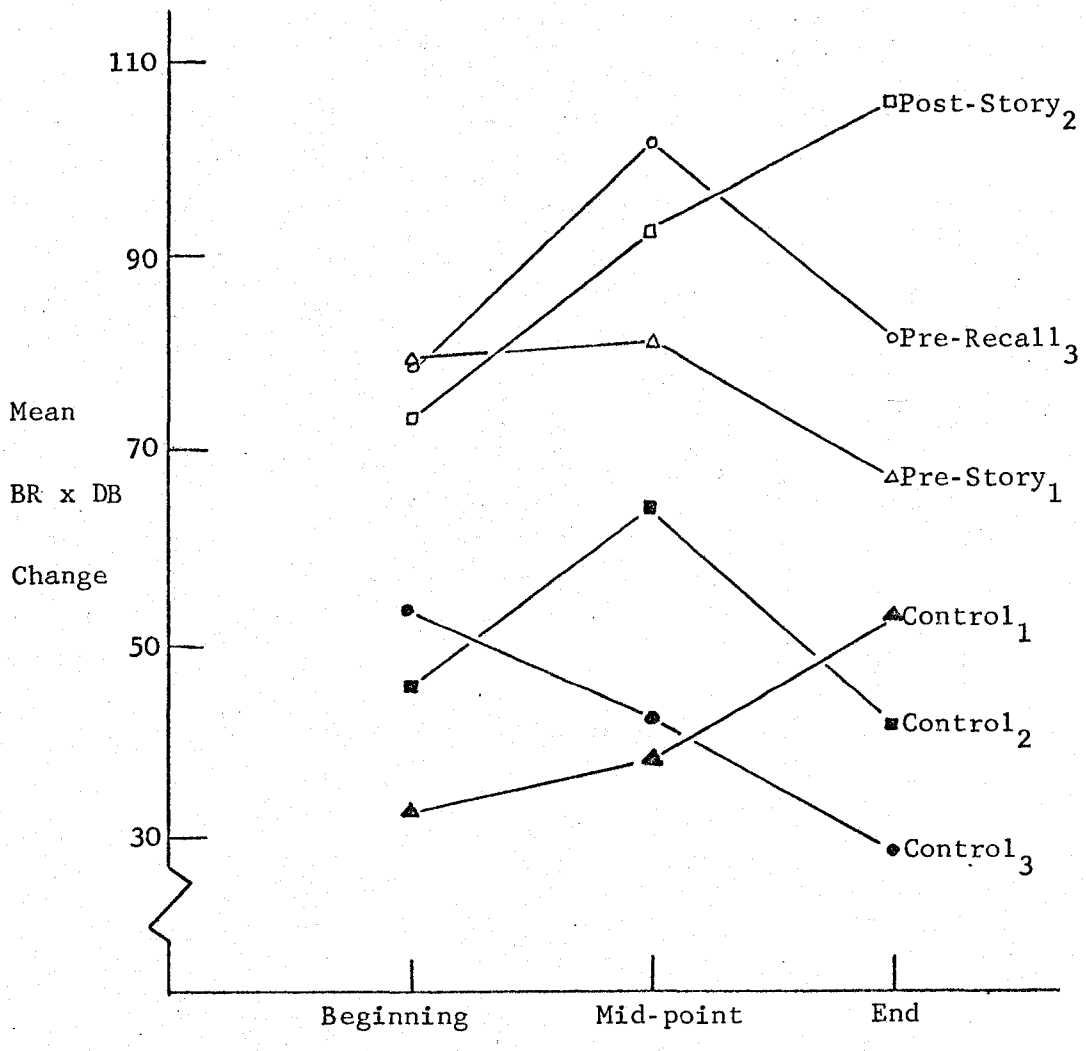

Figure 8. Mean absolute BR x DB change during RDT presentation.

levels of absolute change. The variations across the recording intervals for any one of the treatment groups, however, were not similar to those of its own Control; eg., Pre-Story showed little change in mean absolute BR x DB change from the beginning to the mid-point in RDT presentation, but a decrease from the mid-point to the end, whereas its control, $Control_1$, manifested an increase in mean BR x DB change across the three recording intervals.

To determine whether the differences in mean absolute BR x DB changes noted in Figure 8 were statistically significant and thereby test Hypothesis I as it pertains to breathing changes, three analyses of variance were conducted. The first of these analyses, a summary of which appears in Table 8, is a two-way analysis of variance with $treatment_1$ and time as the main effects. None of the $\underline{F}$ ratios was significant

Table 8

Two-Way Analysis of Variance of BR x DB Changes During RDT With $Treatment_1$ and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	1	11,934.86	2.12
Error (tr)	12	5,627.57	
Time (T)	2	87.89	0.05
Tr x T	2	1,146.72	0.60
Error (t)	24	1,903.07	

indicating that Pre-Story and Control BR x DB changes did not differ significantly nor vary over time during the period of RDT presentation. Thus, Hypothesis I, which predicted significant increases in arousal as reflected in breathing changes during RDT, was not upheld in this case.

Similar findings resulted when BR x DB changes shown by $Control_2$ and Post-Story groups were subjected to a two-way analysis of variance with $treatment_2$ and time as main effects. A summary of this analysis appears in Table 9. None of the F ratios was significant. In this case also, Hypothesis I was rejected.

Table 9

Two-Way Analysis of Variance of BR x DB Changes During RDT with $Treatment_2$ and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	1	16,199.46	1.91
Error (tr)	12	8,487.89	
Time	2	1,262.88	0.24
Tr x T	2	1,532.41	0.30
Error (t)	24	5,159.99	

The third analysis of variance which was carried out for BR x DB changes during RDT had $treatment_3$ and time as main effects. A summary of this analysis, presented in Table 10, shows the F ratio for treatment to be significant at the 0.10 level. This indicates that the Control group and the Pre-Recall group had been significantly differentiated.

Table 10

Two-Way Analysis of Variance of BR x DB Changes During RDT With $Treatment_3$ and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	1	21,539.70	4.41*
Error (t)	12	4,877.04	
Time (T)	2	1,032.12	0.48
Tr x T	2	1,239.40	0.58
Error (t)	24	2,144.87	

* $F_{.90}(1,12) = 3.18$

Summary of Results for Hypothesis I

It was hypothesized that the RDT would produce a significant increase in arousal as reflected in changes in HR and/or BR. As far as HR changes were concerned, Hypothesis I was upheld in only one instance, that in which the RDT was presented immediately after the story. In the other two conditions, those in which the RDT was presented either immediately before the story or immediately before recall, HR changes did not differ significantly from those found in the Control group at the same periods of time. Therefore, Hypothesis I, as it related to HR changes was not upheld in these two instances.

As far as BR was concerned, Hypothesis I as originally stated, could not be directly tested since it was not possible to establish basal BR scores from which to measure the predicted changes. A multiplicative breathing measure (BR x DB) which incorporated rate as

well as amplitude of breathing was employed instead. When BR x DB scores were subjected to analyses, statistical findings indicated that Hypothesis I, as it related to changes in breathing, should be rejected with one exception. The RDT did produce significant increases in arousal as reflected in BR x DB changes in the group to whom it was presented immediately before recall.

In summary, then, it can be stated that Hypothesis I was upheld in two analyses, those pertaining to HR changes in the Post-Story group and BR x DB changes in the Pre-Recall group. In the other four analyses, Hypothesis I was not upheld.

Hypothesis II

It was hypothesized that material presented during increased arousal conditions would show poorer immediate recall and stronger delayed recall than material presented under neutral conditions. That is, it was expected that those groups to whom the RDT was presented would recall the story more completely and more accurately than would the control group to whom the RDT was not presented, when recall was one day later. The opposite results were expected when recall followed immediately (7 minutes) after the story was read.

Each S received one score for each of the four scoring categories on each of the two recalls (immediate and delayed). These data appear in Appendix G, but are represented by mean recall scores in the four scoring categories for each experimental group at both immediate and delayed recall as presented in Table 11. Inspection of these means and the graphical representation of Content Word (CW) means in Figure 9 indicates that the Pre-Recall group showed the best recall over both

Table 11

Mean Recall in Each Category for Each Group
Under Immediate and Delayed Conditions

Category Group	Immediate	Delayed
Content Words		
Control	89.71	88.71
Pre-Story	91.43	91.28
Post-Story	76.43	71.00
Pre-Recall	108.00	104.28
Words Produced		
Control	174.43	190.71
Pre-Story	175.14	182.57
Post-Story	147.57	158.56
Pre-Recall	193.86	200.00
Words to Maximum		
Control	79.00	78.28
Pre-Story	83.14	82.57
Post-Story	70.43	64.71
Pre-Recall	95.71	92.43
Words Scored Once		
Control	49.14	45.57
Pre-Story	48.71	48.86
Post-Story	42.00	40.57
Pre-Recall	56.71	54.71

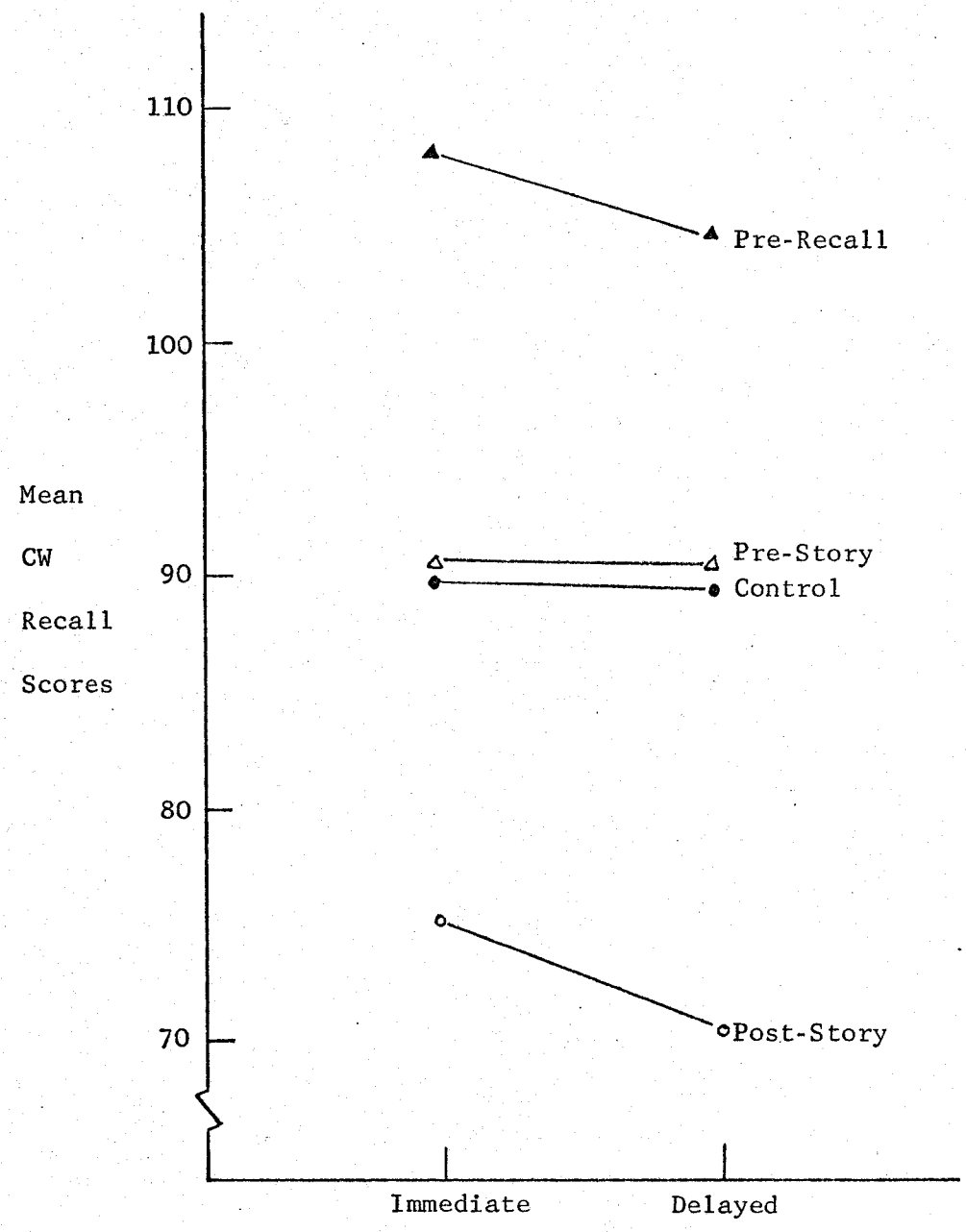

Figure 9. Mean CW recall scores as a function of recall interval.

immediate and delayed conditions, and the Post-Story group, the poorest, with the Control group and the Pre-Story group falling in intermediate positions. In view of the fact that such was the case regardless of scoring method, a multi-correlational analysis was conducted to ascertain the magnitude of the relationships which appeared to exist between the four different types of recall scores in both the immediate and delayed conditions. The resulting correlational matrices are presented in Table 12.

High intercorrelations were found between all the scoring categories as shown in Table 12. The near perfect correlations between Content Word (CW), Words to Maximum (WM), and Words Scored Once (WO) scores suggest very strongly that they are, for all intents and purposes, measures of the same thing. This finding is not surprising in view of the fact that the latter two types of scores (WM and WO) are based on the former (CW). Correlations between the above three scores and Words Produced (WP) scores were slightly lower, especially under conditions of delayed recall. These lower correlations suggest that WP scores reflect some aspect of recall over and above that of content *per se*. In view of the magnitude of the correlations, however, that which WP scores reflect was considered insufficient to warrant the presentation of their analyses in any tests of Hypotheses II, III, IV, or V.

To test the predicted interaction between arousal condition (RDT) and recall interval (Hypothesis II), CW scores were subjected to a two-way analysis of variance with arousal and time as main effects. Because the question here was not that of differences between treatment groups, but rather that of differences between all groups to whom the

Table 12

Correlations Between Scores in the Four Scoring Categories for Immediate and Delayed Recall

	Immediate				Delayed			
	CW	WP	WM	WO	CW	WP	WM	WO
CW		.92	.98	.96		.85	.99	.98
WP			.88	.86			.80	.78
WM				.98				.98

RDT had been presented and the Control group who were not exposed to the RDT, treatment groups were collapsed and their recalls compared with those of the Controls. Thus, the analysis of variance employed unequal cell frequencies using the least-squares solution. A summary of this analysis is presented in Table 13.

Table 13

Two-Way Analysis of Variance of the CW Recall Scores With Arousal and Time as Main Effects

Source	df	Mean Square	F Ratio
Arousal (A)	1	14.88	0.01
Error (a)	26	1783.78	
Recall Interval (R)	1	92.57	1.77
AR	1	11.53	0.22
Error (r)	26	52.77	

None of the F ratios was significant indicating that the arousal condition (RDT) did not significantly differentiate between the treatment groups and the control in terms of their immediate and delayed recall scores. Therefore, Hypothesis II was not upheld. This finding is reasonably consistent with the results of analyses which tested Hypothesis I wherein it was discovered that the arousal condition (RDT) did not generally produce differential arousal (HR and/or BR x DB) effects.

Hypothesis III and IV

It was hypothesized (Hypothesis III) that material whose presentation is immediately followed by increased arousal conditions will show poorer immediate and delayed recall than material preceded by increased arousal conditions, material whose recall is preceded by increased arousal conditions, or material presented under neutral conditions. In other words, it was expected that the group to whom the RDT was presented immediately following the story would show lower recall scores than would the other three groups. In addition, it was hypothesized (Hypothesis IV) that material whose recall is immediately preceded by increased arousal conditions will show better immediate and delayed recall than material preceded or followed by increased arousal conditions or material presented under neutral conditions. That is, it was expected that the group to whom the RDT was presented immediately prior to the recall period (Pre-Recall) would produce higher recall scores than would the other three groups.

In order to test Hypotheses III and IV, CW recall scores were subjected to a two-way analysis of variance with arousal and recall

interval as main effects. A summary of this analysis appears in Table 14. None of the F ratios was significant. Due to the a priori expectations concerning the effects of the placement of the increased arousal condition (RDT) on subsequent recall, relevant selected a priori comparisons of total recall scores were conducted.

Table 14

Two-Way Analysis of Variance of the CW Recall Scores

Source	df	Mean Square	F Ratio
Arousal (A)	3	2,465.07	1.52
Error (a)	24	1,624.92	
Recall Interval (R)	1	92.57	1.68
AR	3	20.81	0.38
Error (r)	24	55.04	

When the total recall scores produced by Post-Story were compared, according to the procedure outlined by Winer (1962, p. 69), with those of the other three groups, a significant ($p = 0.10$) difference was found. Therefore, with the proviso attached to such a confidence level, it can be stated that Hypothesis III was upheld. A similar significant finding resulted when the total recall scores produced by the Pre-Recall group were compared with those of the other three groups. Therefore, Hypothesis IV was also upheld. For interest's sake, however, an additional comparison was conducted between Post-Story and Pre-Recall totals which resulted in the establishment of a significant ($p = 0.05$) difference between the two. Such a difference undoubtedly contributed to

the significant differences in recall which obtained between each of these two groups and the other three. In summary, however, it can be stated that Hypothesis III, which predicted the lowest recalls for Post-Story, and Hypothesis IV, which predicted the highest for Pre-Recall, were confirmed.

Hypothesis V

It was hypothesized that material presented during "high" arousal would show poorer immediate recall and stronger delayed recall than would material presented under "low" arousal. As a prelude to testing this hypothesis, Ss were ordered into either "high" or "low" arousal groups on the basis of mean HR changes during the presentation of the story. The actual ordering of the Ss was accomplished in the following manner. A median split was employed; i.e., those Ss whose mean HR during the story was less than 5 beats per minute different from basal HR were designated as the "low" arousal group; those Ss who manifested a HR greater than 5 beats per minute from base were designated the "high" arousal group. The groups so constituted are presented in Appendix H. There it will be noted that three Ss had mean HR changes which fell at the median. In order to preclude unequal cell frequencies, an arbitrary decision rule was introduced. Those Ss whose HR change was as high as 9 at one of the three (beginning, mid-point, and end) sampled times during the story presentation would be considered as "high" arousal group members; those Ss whose mean HR change during story was 5, but at no point was as high as 9, would be included in the "low" arousal catagory.

Having thus collapsed groups across treatment conditions for within

subject analysis of arousal (HR) and recall interval, the pattern which emerged is that which is presented in Figure 10. The means from which the co-ordinates in this figure were drawn, as well as the means for the other three recall scoring categories, are presented in Table 15 for both immediate (IR) and delayed (DR) recall.

Inspection of Table 15 shows that the HA group had consistently better recall scores, regardless of scoring category, across both recall intervals than did the LA group. An additional finding of no small importance however, is that the DR content scores (CW, WM and WO) obtained by HA were essentially the same as those obtained by that group at IR. A similar finding did not emerge for the LA group. Rather, their DR scores reflected a decrement of five per cent or greater compared with their IR scores.

Thus, not only did high arousal, as reflected in mean HR change during story presentation, improve IR, it sustained that increment over the 24-hour delayed recall interval. On the other hand, the lower recall scores achieved by LAs were even lower after the one-day delay. To determine whether this suggested interaction between arousal and recall interval was significant, as well as to assess the degree of differences between the arousal groups and recall intervals, two-way analyses of variance of the recall scores were carried out.

The most pertinent analysis, presented in Table 16, is that of CW recall scores with arousal and recall interval as main effects. Here it can be seen that arousal significantly differentiated the two groups in terms of their overall recall performance ($p = 0.05$), but the F ratios for the recall interval and interaction between arousal and

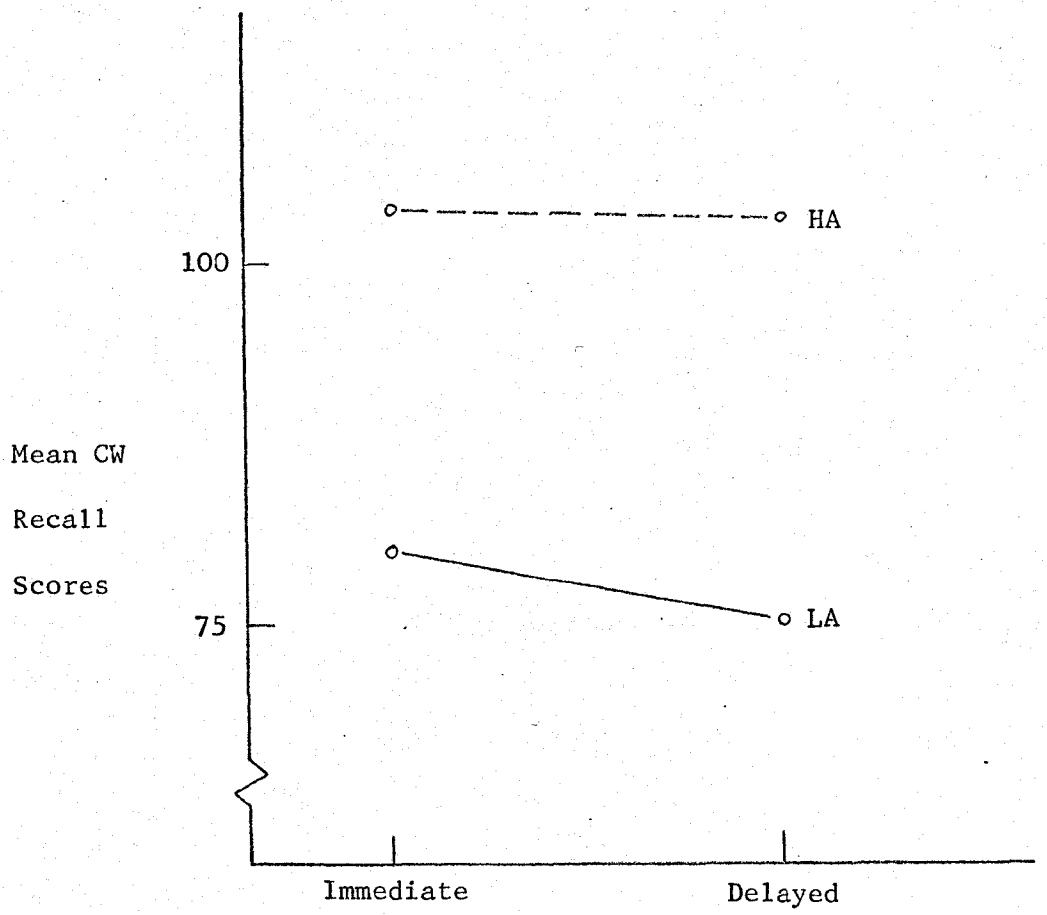

Figure 10. Mean CW recall scores as a function of arousal level and recall interval.

Table 15

Mean Recall Scores (IR and DR) for the HA and LA Groups

Category Group	Immediate	Delayed
Content Words		
High Arousal	103.00	102.50
Low Arousal	79.79	75.14
Words Produced		
High Arousal	188.93	200.86
Low Arousal	156.57	165.22
Words to Maximum		
High Arousal	92.57	92.29
Low Arousal	71.57	66.71
Words Scored Once		
High Arousal	55.00	54.43
Low Arousal	43.29	41.43

recall interval failed to reach significant levels. Similar findings

Table 16

Within Subject Analysis of Variance of CW Recall Scores

Source	df	Mean Square	F Ratio
Arousal (A)	1	8,951.14	6.22*
Error (a)	26	1,440.08	
Recall Interval (R)	1	92.57	1.68
A x R	1	20.03	0.36
Error (r)	26	55.14	

* $F_{.95}(1,26) = 4.23$

resulted from analyses of variance of the other three (WP, WM and WO) types of recall scores. That is, the recall scores were significantly ($p = 0.05$) different for the HA and LA groups, but the interaction and recall interval effects were non-significant. There was, however, one exception. The F ratio for recall interval was significant ($p = 0.01$) when the recall scores subjected to analysis were those arrived at employing the WP scoring procedure. When this finding is viewed within the framework of Table 15, then it can be appreciated that significantly more words were produced (by both HA and LA groups) in writing recalls one day later than were used in writing immediate recalls. This finding parallels similar differences between immediate and delayed recalls (WP scores) seen in Table 11 above.

Taking into consideration the results of analysis of variance

conducted for the CW recall scores, as well as those of WP, WM and WO, it can be stated that Hypothesis V which predicted an interaction between arousal level and recall interval was not upheld. The "high" arousal group did, however, produce better recalls than did the "low" arousal group, but the HA recalls were better at both immediate and delayed intervals whereas it was hypothesized that the "high" arousal recall would be inferior to the "low" arousal at the immediate test.

In summary, then, it can be stated that Hypothesis V, which predicted that material presented during "high" arousal would show poorer immediate recall and stronger delayed recall than would material presented during "low" arousal, was not confirmed. Such was the case regardless of scoring category. That is, analyses of CW, as well as WP, WM and WO recall scores, ordered into either "high" or "low" arousal categories on the basis of HR changes during the story presentation, failed to produce results which would warrant the upholding of Hypothesis V.

It should be pointed out that the testing of Hypothesis V was carried out having ordered Ss into "high" and "low" arousal groups on the basis of mean HR change during the story. Br x DB changes showed very little correlation ($r = .11$) with HR changes occurring at the same time. Therefore, it seemed unnecessary, as well as unwise (See Discussion, p. 123) to take the BR x DB changes during story into consideration when ordering Ss into the "high" and "low" arousal groups for the testing of Hypothesis V.

Phenomenological Results

Expectations related to the phenomenological aspects of the current study were tested through analyses of the Recollection Rating Scale (RRS) data which is presented in Appendix I. Each S received two scores (his own ratings) on each of four scales: pleased - displeased (P-D), indifferent - aroused (I-A), accepting - rejecting (A-R), and puzzled - comprehending (P-C). The scores on specific, appropriate scales of the RRS were used in testing Expectations 1, 2, 3, and 5. To test expectations 4 recall (CW) scores were the data employed, but the ordering of Ss into categories was accomplished on the basis of their RRS scores.

Expectation 1

It was expected that those Ss who showed cardiac deceleration (decrease in HR) during the experiment would recollect that they had felt more accepting than those Ss who showed cardiac acceleration (increase in HR). Those Ss who manifested cardiac deceleration as reflected in a decrease from their established basal rates were designated "decelerates". Samples of HR taken during the RDT and story presentation periods were used in arriving at this designation. S who manifested cardiac acceleration as reflected in an increase from their basal rates were categorized as "accelerates". Since only one S (S_{10}) did not show either an increase or a decrease in HR during RDT or story presentation, it was possible to employ the data from 27 Ss in analyzing the accepting - rejecting scale ratings as a test of Expectation 1. The ordering of Ss carried out according to the above outlined procedure is presented in Appendix J.

The mean ratings given at the end of the immediate (IR) and delayed (DR) recall intervals by the decelerates and accelerates on the accepting - rejecting (A-R) scale of the RRS are presented in Table 17. Inspection of this table indicates that the accelerates did recollect that they had felt less accepting during the experiment than did the decelerates. In addition, the degree of their recollected feelings of acceptance was approximately the same regardless of whether their recollection was made at IR or DR, whereas the decelerates manifested a decrease in the degree of their recollected feelings of acceptance at DR.

Table 17

Mean A-R Ratings Made by Decelerates and Accelerates At Immediate and Delayed Recall

	IR	DR
Decelerates	3.75*	5.38
Accelerates	6.53	6.32

* The lower the rating, the more accepting.

In order to test Expectation 1, the accepting - rejecting ratings, from which the means in Table 17 were calculated, were subjected to a two-way analysis of variance with Direction (of HR change) and Recall Interval as main effects. Since 8 Ss manifested cardiac deceleration, whereas 19 Ss showed an increase in HR, the analysis employed unequal cell frequencies using the least squares solution. A summary of that analysis, as presented in Table 18, indicates that none of the F ratios

Table 18

Two-Way Analysis of Variance of Accepting - Rejecting Ratings With Direction and Recall Interval as the Main Effects

Source	df	Mean Square	F Ratio
Direction (D)	1	39.99	1.66
Error (d)	25	24.01	
Recall Interval (R)	1	1.85	0.54
D x R	1	8.95	2.59
Error (r)	25	3.45	

are significant. That is, the decelerates were not differentiated from the accelerates on the basis of accepting - rejecting scale ratings; the ratings did not vary significantly over the recall intervals, nor was there an interaction between direction of HR change and recall interval. Thus, because significant differences were not established between the ratings of the decelerates and the accelerates, Expection 1, which predicted that Ss who show cardiac deceleration would recollect that they felt more accepting during the experiment than would Ss who show acceleration, was not confirmed.

Expectations 2 and 3

It was expected (Expectation 2) that those Ss exposed to the RDT during the experiment would recollect that they felt less comprehending than would the control Ss to whom the RDT was not presented. And further, it was expected (Expectation 3) that Ss presented with the RDT would recollect that they felt more aroused than would the controls. In order

to test these two expectations, treatment groups (to whom the RDT had been presented) were collapsed and their puzzled - comprehending (P-C) and indifferent - aroused (I-A) scale ratings were compared with those of the control group. The mean scale ratings made by each group at both immediate (IR) and delayed (DR) recall are presented in Table 19.

Table 19

Mean P-C and I-A Ratings Made by the Treatment and Control Groups at Immediate and Delayed Recall

Group	P-C*		I-A**	
	IR	DR	IR	DR
Control	12.14	11.57	12.28	11.71
Treatment	8.10	8.24	13.95	13.67

* The higher the score, the more comprehending.
** The higher the score, the more aroused.

Inspection of Table 19 indicates that the Control Ss did recollect that they felt more comprehending than did the treatment Ss. To determine whether the difference between these two groups in their recollections of how comprehending they felt during the experiment were statistically significant, a two-way analysis of variance with treatment and recall interval was carried out for the puzzlied - comprehending ratings. Since treatment groups had been collapsed, unequal cell frequencies analysis using the least squares solution was employed. A summary of this analysis, which appears in Table 20, presents a significant ($p = 0.10$) F ratio for treatment, although the F ratios

Table 20

Two-Way Analysis of Variance of Puzzled - Comprehending Scale Ratings With Treatment and Recall Interval as the Main Effects

Source	df	Mean Square	F Ratio
Treatment (T)	1	143.00	3.74*
Error (t)	26	38.25	
Recall Interval (R)	1	0.01	0.01
T x R	1	1.34	0.69
Error (r)	26	1.93	

* $F_{.90}(1,26) = 2.91$

for recall interval and the interaction between recall interval and treatment were not significant. This indicates that the treatment and control groups were significantly differentiated on the basis of their P-C scale ratings and that their ratings were consistent over recall interval. When this significant difference is viewed within the framework provided by Table 19 in which mean P-C ratings made by the two groups were presented, it can be stated that Expectation 2 was confirmed. In other words, those Ss who were exposed to the RDT during the experiment recollected that they felt less comprehending than did the control Ss.

Expectation 3

It was expected that the treatment Ss having been exposed to the RDT, would recollect that they felt more aroused than would the controls. To test this prediction, the indifferent - aroused (I-A) ratings, the

means of which were presented in Table 19, were subjected to a two-way analysis of variance with treatment and recall interval as main effects. As was the case with the analysis of P-C ratings, unequal cell frequencies were employed using the least squares solution. A summary of this analysis, presented in Table 21, shows that none of the F ratios was significant. Therefore, it can be stated that Expectation 3 was not confirmed.

Table 21

Two-Way Analysis of Variance of Indifferent - Aroused Scale Ratings With Treatment and Recall Interval as Main Effects

Source	df	Mean Square	F Ratio
Treatment (T)	1	34.38	1.31
Error (t)	26	26.33	
Recall Interval (R)	1	1.79	2.32
T x R	1	0.21	0.27
Error (r)	26	0.77	

In summary, then, it can be stated that the treatment Ss having been presented with the RDT, were significantly ($p = 0.10$) less comprehending (at least as far as their recollections of how they had felt during the experiment were concerned) than were the controls. Thus, Expectation 2 was confirmed. Analysis of variance carried out for the indifferent - aroused ratings failed to show any differences between the treatment Ss and the controls. Therefore, Expectation 3, which predicted that the treatment Ss would recollect having felt more aroused

than would have the controls, was not confirmed.

Expectation 4

It was expected that those Ss who recollected that they felt more accepting during the experiment would produce better recalls than would those Ss who recollected that they felt more rejecting. As a prelude to testing this expectation, all groups were collapsed and Ss were assigned to either the "rejecting" or "accepting" group according to the following criterion. Any Ss who used a rating of 9 or greater on either occasion when presented with the RRS was assigned to the "rejecting" group. Inspection of the RRS data, which appears in Appendix I, indicates that such an ordering procedure included 9 Ss in the "rejecting" group. The remaining 19 Ss were designated as "accepting".

The mean CW recall scores obtained by these two groups at immediate and delayed recall are presented in Table 22.

Table 22

Mean CW Recall Scores at IR and DR for Accepting and Rejecting Ss

Group	Immediate Recall	Delayed Recall
Rejecting	98.78	89.33
Accepting	87.89	88.57

Inspection of Table 22 indicates that, contrary to Expectation 4, the rejecting group manifested the superior recall, although the higher recall rate was not sustained over the delayed interval. To determine if these differences between the groups were significant, and thereby test

Expectation 4, the CW recall scores of the accepting and rejecting groups were subjected to an unequal cell frequencies analysis of variance in which Acceptance and Recall Interval were the main effects. A summary of that analysis appears in Table 23.

Table 23

Two-Way Analysis of Variance of CW Recall Scores With Acceptance and Recall Interval as the Main Effects

Source	df	Mean Square	F Ratio
Acceptance (A)	1	413.54	0.23
Error (a)	26	1,768.45	
Recall Interval (R)	1	92.57	2.25
A x R	1	313.27	7.61*
Error (r)	26	41.16	

* $F_{.95}(1,26) = 4.23$

Although neither the F ratio for acceptance or recall interval was significant, the interaction between these two effects was significant ($p = 0.05$). Because of the latter finding a simple effects analysis was carried out. Results of this analysis indicated that level of acceptance did not differentiate the groups in terms of their recall scores at either IR or DR. On the other hand recall scores were differentiated ($p = 0.01$) at the two recall intervals for the rejecting group. Such was not the case, however, for the accepting group, although their DR scores are slightly enhanced. The rejecting group manifested a significant decrement over the delayed interval. Therefore,

Expectation 4, which predicted that it would be the accepting group who had the superior recall, was not confirmed. A proviso, however is in order here. Although the accepting group did not show better recall as predicted, the results indicated that this group did now show forgetting over the delayed interval whereas the rejecting group did show such a retention decrement.

Expectation 5

It was expected that those Ss who were ordered into the "high" arousal condition on the basis of HR and/or BR changes at the time of story presentation would recollect that they felt more aroused than would those Ss who were ordered into the "low" arousal condition. The ordering of Ss was accomplished in the manner outlined in the section above which pertained to the testing of Hypothesis V (See p. 83).

Although it is the indifferent - aroused scale which is of particular interest in testing Expectation 5, the mean RRS ratings for the other three scales are also presented graphically in Figure 11. As can be seen in this figure, the differences in indifferent - aroused (I-A) ratings made by the high (HA) and low (LA) arousal groups were in the direction of the prediction made in Expectation 5. They were not, however, of sufficient magnitude to warrant an individual analysis of variance of the I-A ratings. Rather, it seemed reasonable to assume that the differences were not significant, and thereby conclude that Expectation 5 was not confirmed.

Further inspection of Figure 11 indicated that the RRS profiles for the HA and LA group were essentially the same at IR, but that differences obtained between the two groups at DR. To investigate these

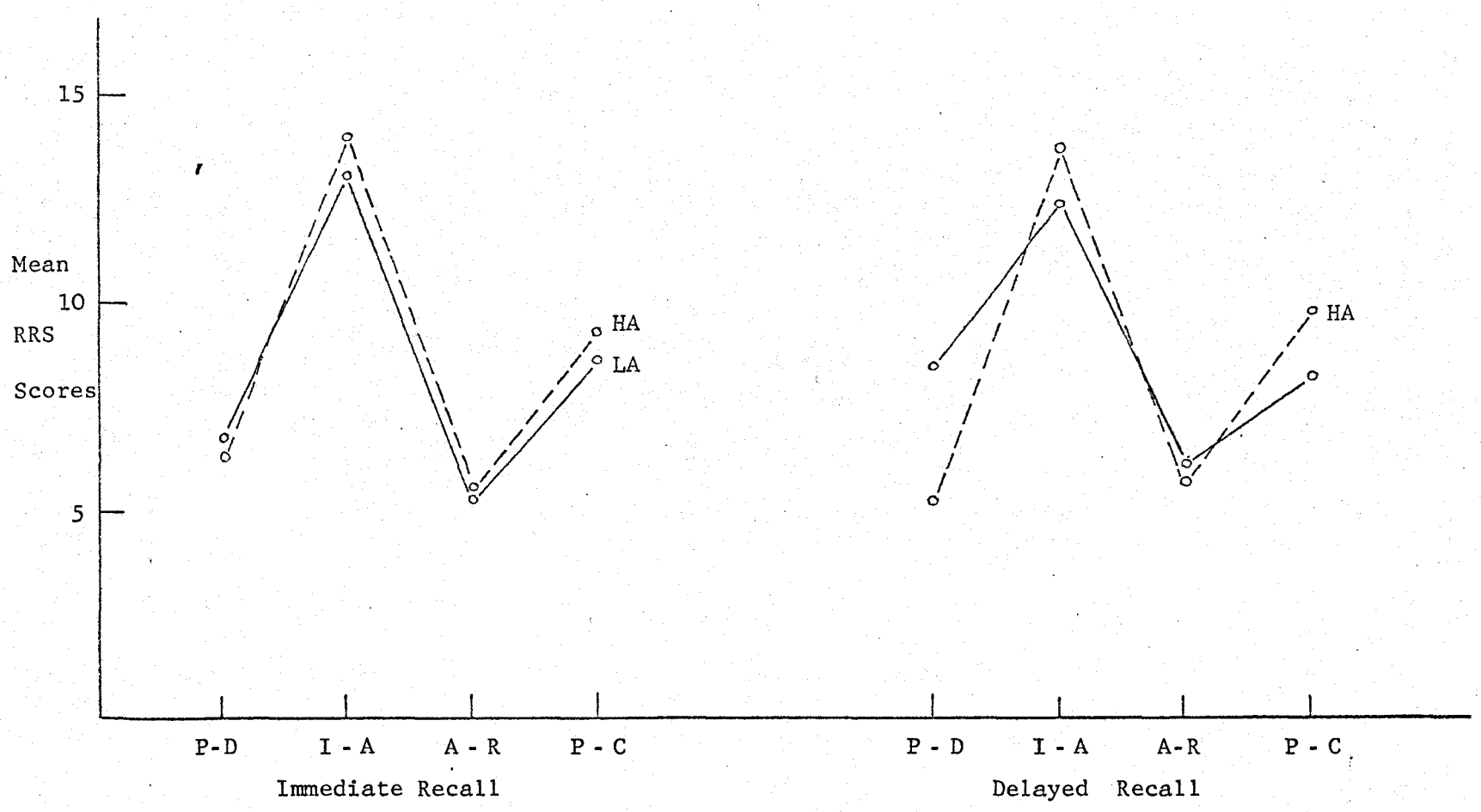

Figure 11. RRS scores as a function of arousal level, scale and recall interval.

differences a three-way analysis of variance with arousal, recall interval and scale as main effects was performed for the RRS ratings. A summary of this analysis appears in Table 24, inspection of which indicates that the F ratio for scale, as well as for the three-way interaction, was significant. Although statistically significant, the scale factor difference is of little psychological significance since the four scales represent four bipolar orthogonal factors (See McCarter, 1961). On the other hand, however, the significance ($p = 0.05$) of the interaction between arousal, recall interval and scale is of no small importance. Inspection of Figure 11 shows that the HAs at DR recollected that they felt less displeased and more comprehending than their earlier (IR) recollections indicated. The opposite was the case for LAs: at DR they recollected as having felt more displeased and less comprehending than they had at IR.

In summary, then, it can be stated that Expectation 5 which predicted higher arousal (I-A) ratings for the HA group than for the LA group was not confirmed. Analysis of variance of scores on all four RRS scales, however, uncovered some interesting findings regarding differences between the HA and LA ratings at DR. The HA group manifested a decrease in their pleased - displeased ratings and an increase in their puzzled - comprehending ratings; for LA the reverse was found.

Table 24

Within Subject Analysis of Variance of RRS Ratings With Arousal, Recall Interval, and Scale as Main Effects

Source	df	Mean Square	F Ratio
Arousal (A)	1	0.45	0.01
Error (a)	26	32.52	
Recall Interval (R)	1	0.45	0.19
A x R	1	1.87	0.79
Error (r)	26	2.37	
Scale (S)	3	637.80	22.71*
A x S	3	27.77	0.99
Error (s)	78	28.08	
R x S	3	1.77	0.77
A x R x S	3	9.32	4.05**
Error (rs)	78	2.30	

* $F_{.99}(3,60) = 4.13$ ** $F_{.95}(3,60) = 2.76$

Additional Relevant Results

Although they did not bear directly on the testing of the hypotheses or expectations, there were additional research findings which warranted presentation and analyses because of their relevance to the theoretical issues involved in the discussion of those results which did attend the testing of the hypotheses. These findings include additional analyses of arousal measures taken during RDT presentation to the treatment groups. Results which pertain to arousal during the story, as well as to arousal during IR, are also presented. Arousal as a function of sex is included since both males and females participated in the study. Recall as a function of sex is also included. In addition, reading time; i.e., the time required by the Ss to read the story twice, and memory time; i.e., the time required to write the reproductions, are presented.

Arousal During RDT

Analyses of variance which investigated the magnitude of differences in HR change between the groups and the control group were presented in the section above which dealt with Hypothesis I (see pp. 72-75). To determine whether the presentation of RDT at different times during the learning - recall sequence differentially affected the three treatment groups in terms of arousal as reflected in HR change, an additional analysis was required. This involved a two-way analysis of variance of HR changes for the three treatment groups across the three recording points in RDT presentation. A summary of this analysis which appears in Table 25 presents F ratios which are not significant. These findings indicate that the RDT did not differentiate between the three treatment groups on the basis of HR change and that HR changes across the three recording

points did not vary significantly. The latter finding parallels similar outcomes presented in Tables 4, 5, and 6.

Table 25

Two-way Analysis of Variance of HR Changes During RDT With Treatment and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	2	228.11	1.72
Error (tr)	18	132.54	
Time (T)	2	17.50	0.91
Tr x T	4	14.68	0.76
Error (t)	36	19.21	

To determine whether the presentation of RDT at different times during the learning - recall sequence differentially affected the three treatment groups in terms of their arousal as reflected in BR x DB changes, a two-way analysis of variance with treatment and time as main effects was carried out for the BR x DB changes during RDT. A summary of this analysis presented in Table 26 shows F ratios which were not significant. This indicates that the RDT did not differentiate between the three treatment groups on the basis of BR x DB changes. In addition, BR x DB changes which occurred at the three recording times did not vary significantly; nor did the interaction between treatment and time reach significance. The latter two findings parallel similar results of the previously reported analyses of BR x DB changes (see Tables 8, 9, and 10).

In summary, it can be stated that the RDT did not produce differential

arousal effects in the three treatment groups. This was the case regardless of whether arousal was defined in terms of HR or BR x DB change.

Table 26

Two-way Analysis of Variance of BR x DB Changes During RDT With Treatment and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	2	1,209.54	0.13
Error (tr)	18	9,095.12	
Time (T)	2	1,237.98	0.26
Tr x T	4	1,120.18	0.24
Error (t)	36	4,728.43	

Arousal During Story

The mean HR changes which occurred at the beginning, mid-point, and end of the time during which the story was being read are presented for each of the four groups in Figure 12. To investigate those differences in HR change during the story, a two-way analysis of variance with treatment and time as main effects was performed for these HR changes. A summary of this analysis, presented in Table 27, indicates that the F ratios for treatment and the interaction were not significant, but the F ratio for time was highly significant. When the means of the three recording times were subjected to tests using the Newman-Keuls procedure, it was found that mean HR change recorded at the beginning of the story presentation was significantly different from the mid-point and end mean HR change at the 0.01 and 0.05 levels respectively.

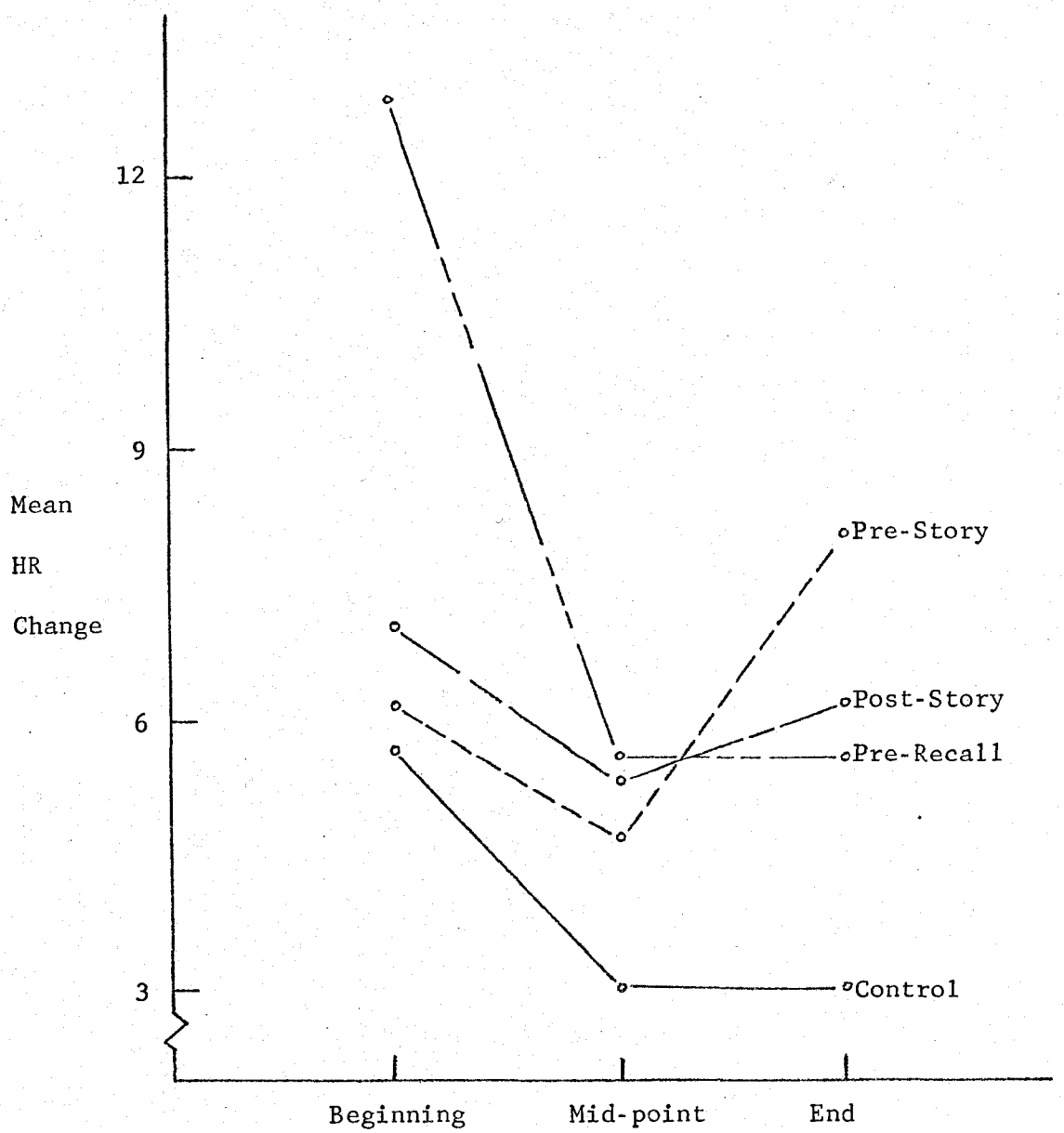

Figure 12. Mean HR change during story presentation.

Table 27

Two-way Analysis of Variance of HR Change During Story With Treatment and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	3	60.71	0.93
Error (tr)	24	65.42	
Time (T)	2	77.18	7.58*
Tr x T	6	28.75	2.82
Error (t)	48	10.18	

*$F_{.99}(2,40) = 5.18$

The mean BR x DB changes recorded at the beginning, mid-point, and end of the time during which the story was being read are presented graphically in Figure 13. Pre-recall showed the greatest overall change in BR x DB. The control group had the second highest BR x DB change, followed closely by Pre-Story, with Post-Story showing the least change. The differences in mean BR x DB change at the beginning of the story between the last three groups were minimal. Differences were much more apparent between all the group at the end of the story presentation. To determine whether these differences in BR x DB change during the story were significant, a two-way analysis of variance of the BR x DB changes was carried out with treatment and time as main effects. A summary of this analysis appears in Table 28. None of the F ratios was significant.

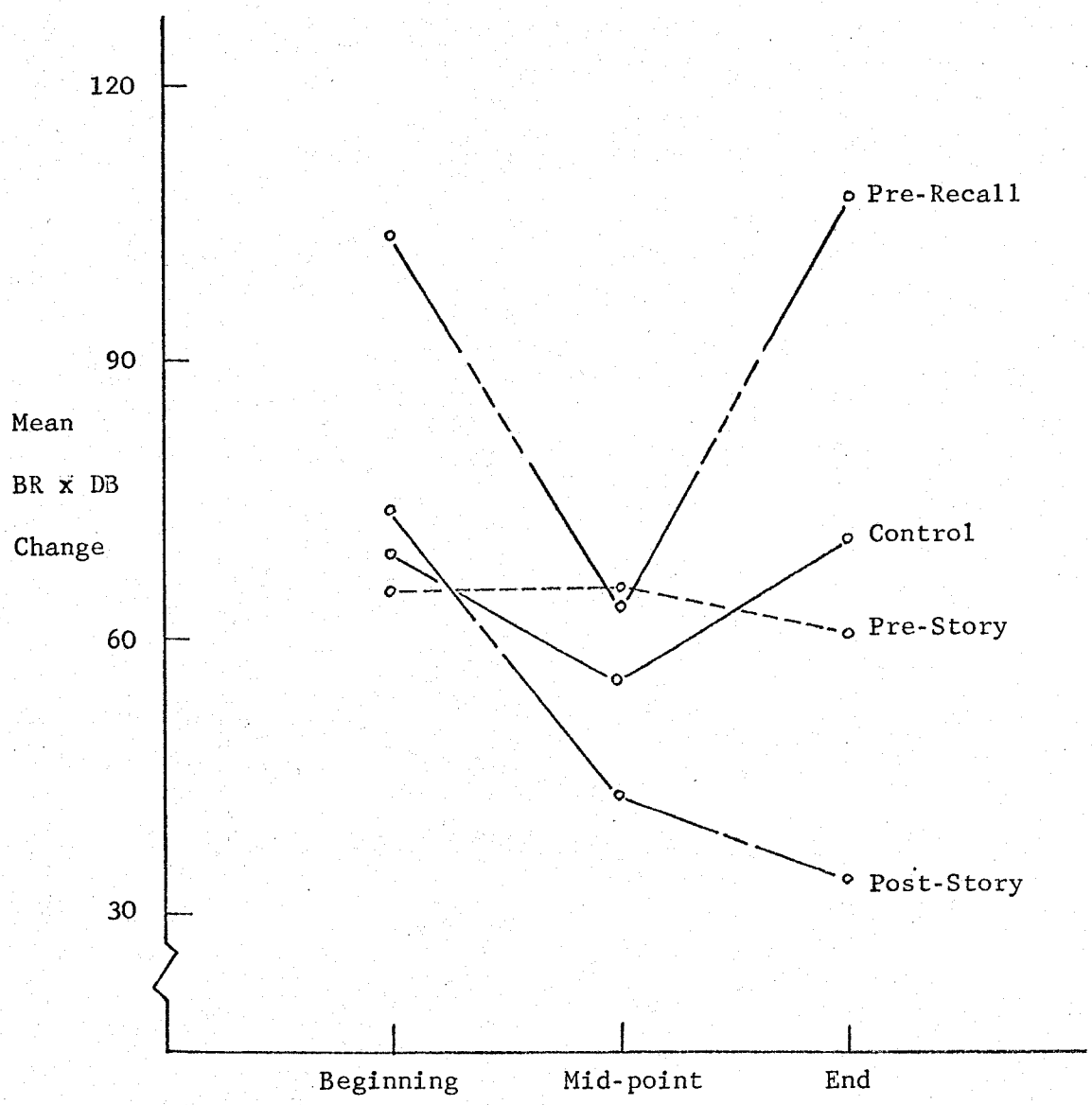

Figure 13. Mean BR x DB change during story presentation.

Table 28

Two-way Analysis of Variance of BR x DB Changes During Story With Treatment and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	3	6,385.88	0.79
Error (tr)	24	8,099.47	
Time (T)	2	3,098.52	0.97
Tr x T	6	1,531.99	0.48
Error (t)	48	3,197.45	

The results of the analyses of HR and BR x DB changes during the story indicated that the four groups were not differentially aroused while reading the story. The importance of these findings will become apparent when the results of analyses which tested Hypotheses III and IV are discussed. The one significant finding which resulted from the analyses of arousal changes during story was the fact that HR at the beginning of the story was significantly different from that at the mid-point and end of the story.

Arousal as a Function of Sex

When treatment groups were collapsed and Ss assigned to either the high arousal (HA) or low arousal (LA) category on the basis of HR change during the story presentation, the ratio of females to males in each arousal category was 8:6. This is exactly the same ratio as that employed in assigning females and males to the original treatment groups. Therefore, it was assumed that sex and arousal were independent in the sample.

When Ss were assigned to HA and LA groups on the basis of BR x DB change during the story, however, the contingencies between sex and arousal were not as expected, but rather, as presented in Table 29, were such that the resulting chi-square reached the 0.10 level of significance. Thus, sex and arousal, as reflected in BR x DB changes, were not independent in the sample. A significantly larger number of males than females fell in the LA category, whereas the opposite was the case in the HA category. These findings suggested that females respond to the kind of story situation presented in the current investigation with greater BR x DB change than do males.

Table 29

Sex - Arousal Contingencies During Story

	HA	LA
Male	3 (1)	9 (2)
Female	11 (3)	5 (4)

Cell	Observed Frequency	Expected
1	3	6
2	9	6
3	11	8
4	5	8

$X = 3.64^*$

* $X_{.90}(1) = 2.70$

Arousal During Immediate Recall

Mean HR changes for the four treatment groups are depicted graphically in Figure 14 as a function of the three recording points during immediate recall (IR). A partial reversal of previously reported changes in HR is shown here. The control group had the greatest overall HR change, followed by Pre-Recall, with Pre-Story and Post-Story showing little difference. A two-way analysis of variance with treatment and time as main effects was performed for the HR changes during IR. A summary of this analysis is presented in Table 30.

Table 30

Two-way Analysis of Variance of HR Changes During Immediate Recall With Treatment and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	3	0.72	0.02
Error (tr)	24	40.96	
Time (T)	2	75.32	3.63*
Tr x T	6	22.75	1.10
Error (t)	48	20.77	

*$F_{.95}(2,40) = 3.23$

The F ratios for treatment and the interaction were not significant, but the F ratio for time was significant at the 0.05 level. When HR change means at the three recording times were subjected to tests employing the Newman-Keuls procedure, it was discovered that mean HR change recorded at the beginning of IR differed significantly ($p = 0.05$) only from that at

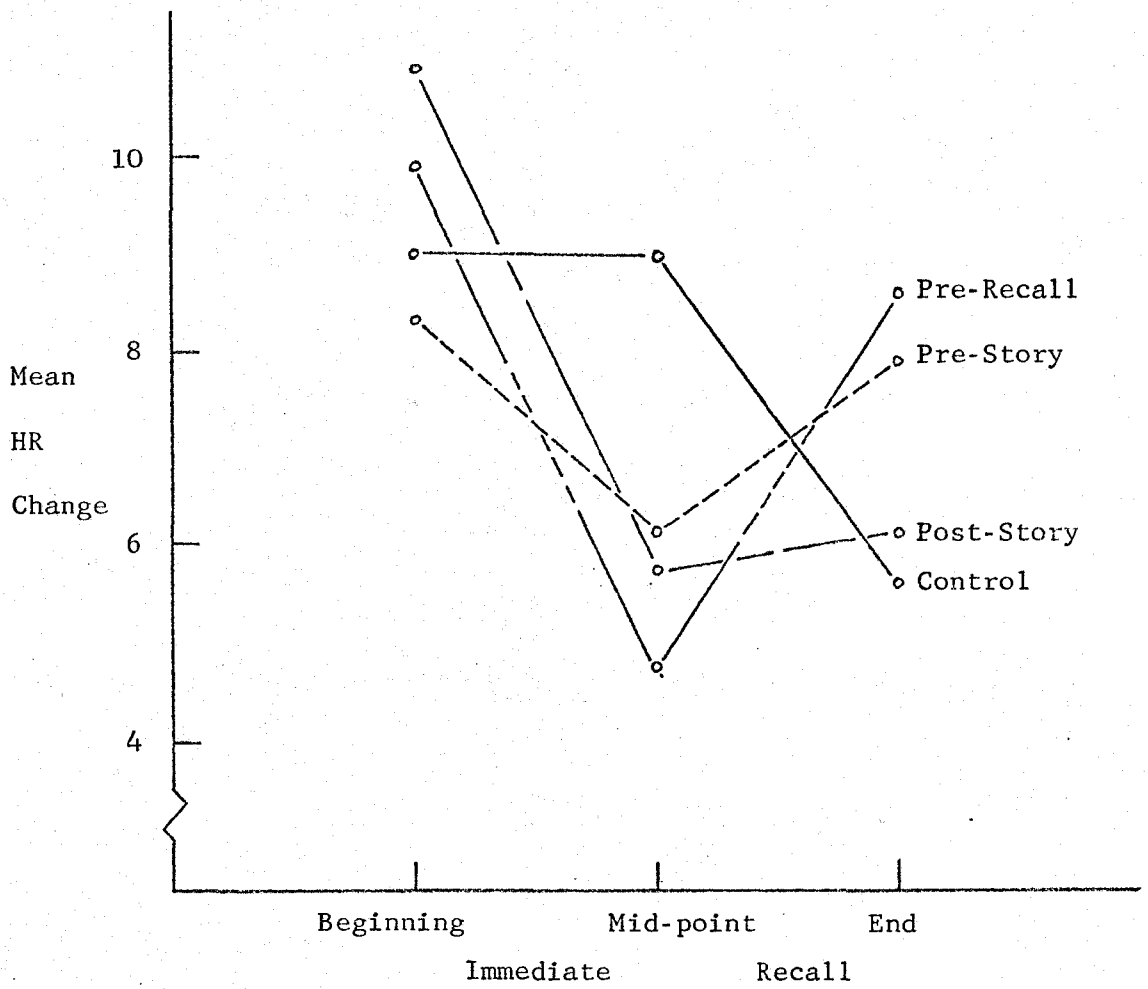

Figure 14. Mean HR change during immediate recall.

the mid-point. Other differences between the means were not significant.

Mean BR x DB changes during IR are presented graphically in Figure 15. Inspection of this figure indicates that the Control group showed the highest increase in BR x DB during IR. A similar finding was shown for their HR change also. Post-Story manifested the second largest change in BR x DB at IR, while small overall differences were shown by the other two groups. To determine whther the differences noted in Figure 15 were statistically significant, a two-way analysis of variance with treatment and time as the main effects was carried out for the BR x DB changes at IR. A summary of this analysis appears in Table 31.

Table 31

Two-way Analysis of Variance of BR x DB Changes During Immediate Recall With Treatment and Time as Main Effects

Source	df	Mean Square	F Ratio
Treatment (Tr)	3	18,964.04	0.89
Error (tr)	24	21,100.48	
Time (T)	2	9,667.88	3.41 *
Tr x T	6	5,423.73	1.91
Error (t)	48	2,836.53	

* $F_{.95}(2,40) = 3.23$

Inspection of Table 31 indicates that the F ratios for treatment and the interaction were not significant. The F ratio for time was significant at the 0.05 level. Using the Newman-Keuls procedure, the mean BR x DB changes which had been recorded at the three different times

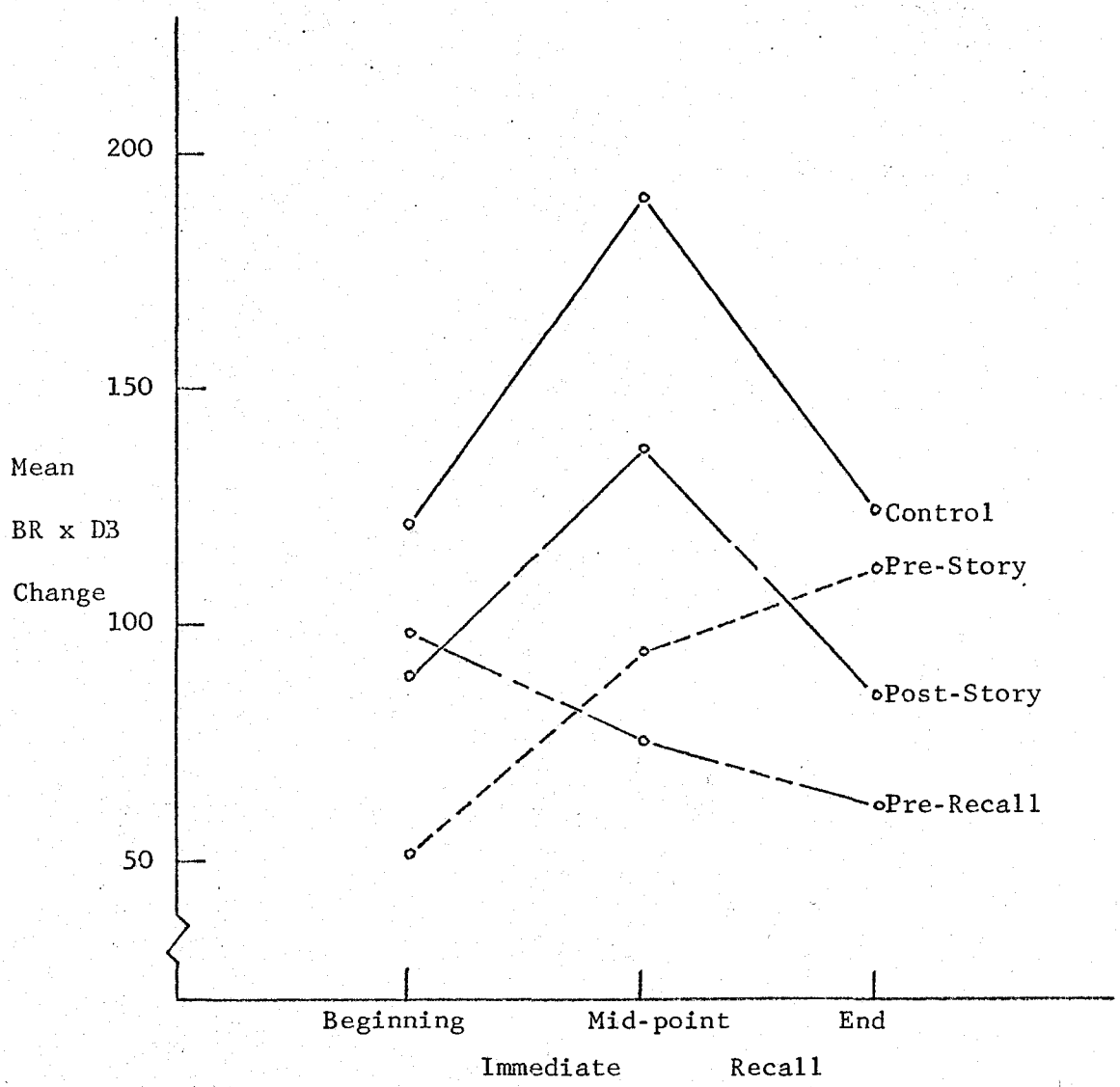

Figure 15. Mean BR x DB change during immediate recall.

during IR were subjected to tests between pairs. The results of these tests indicated that the mean BR x DB recorded at the mid-point in IR was significantly different from that recorded at the commencement of IR. Differences between other pairs of means were not significant.

As was the case with the analysis of HR and BR x DB changes during story, analyses of HR and BR x DB changes which occurred during immediate recall failed to produce F ratios that would indicate that the groups were differentially aroused during immediate recall. Similar findings regarding differences in HR and BR x DB changes over the three recording points during immediate recall resulted. The significant time effects in the HR and BR x DB analyses, however, were found at the same recording points. HR change recorded at the beginning of IR differed from that at the mid-point; BR x DB change at the beginning of IR also differed from that at the mid-point.

Reading Time and Memory Time

In addition to the recall scores and the physiological measures (HR and BR x DB changes), there were two other variables for which the design of the present investigation allowed measurement. These additional parameters were those of reading time and memory time. Reading time (RT) was calculated by measuring the distance from the marker pen deflection which signalled the beginning of the S's reading to the deflection which signalled his having completed the reading task. The pen deflections referred to were those appearing in the lower marker-pen "channel" which were labelled appropriately by E. Memory time (MT) was likewise calculated; that is, a measurement was taken between the two pen deflections marking the beginning and the end of the period during

which the S was writing his recall. RT, as well as MT, measurements were translated from distance measurements in millimetres to time measurements in minutes. The mean RT measures as well as those for MT at both IR and DR appear in Table 32. The raw data from which the means were calculated are presented in Appendix G.

Table 32

Mean Reading Time and Memory Time (Min.)

Group	RT	MT(IR)	MT(DR)
Control	2.70	8.92	8.81
Pre-Story	2.66	8.05	8.42
Post-Story	2.19	7.43	8.08
Pre-Recall	2.64	9.36	8.15

Inspection of Table 32 shows that the Post-Story group had a demonstrably lower mean RT score than the other three groups. To determine whether these differences were statistically significant, a one-way analysis of variance of the RT scores with arousal as the main effect was carried out. A summary of this analysis, which appears in Table 33 shows that the F ratio was not significant.

Table 33

One-Way Analysis of Variance of RT Scores

Source	df	Mean Square	F Ratio
Arousal	3	0.41	1.32
Error	24	0.31	

Table 34

RT - CW Score Contingencies at Immediate Recall

	High CW	Low CW	Totals
Long RT	9 (7)*	5 (7)	14
Short RT	5 (7)	9 (7)	14
Totals	14	14	28

* Expected frequency

Table 35

RT - CW Score Contingencies at Delayed Recall

	High CW	Low CW	Totals
Long RT	8 (7)*	6 (7)	14
Short RT	6 (7)	8 (7)	14
Totals	14	14	28

* Expected frequency

When the RT means in Table 32 are compared with the mean recall scores which were previously presented in Table 11, however, there is suggested a relationship between "short" RT's and "low" recall scores and/or between "long" RT's and "high" recall scores. To investigate the possibility of such relationship(s) existing, contingency tables (see Tables 34 and 35) were set up for CW and RT scores at both recall intervals. The χ^2's which resulted, 1.28 and 0.84, with one degree of freedom were not significant. It can be assumed, therefore, that RT and CW scores were independent in the sample.

To determine whether MT scores differed significantly across arousal group or recall interval, a two-way analysis of variance was carried out. A summary of this analysis in which arousal and recall interval are the main effects, appears in Table 36. None of the F ratios was significant.

Table 36

Two-Way Analysis of Variance of the MT Scores

Source	df	Mean Square	F Ratio
Arousal (A)	3	3.68	0.21
Error (a)	24	17.54	
Recall Interval (R)	1	0.08	0.07
AR	3	2.35	2.16
Error (r)	24	1.09	

The results of the analysis of variance of the MT scores indicates that the experimental groups were not differentiated on the basis of

time required to write their reproductions of the story. In addition, the MT did not vary over the recall intervals to a degree sufficiently high enough to produce significant differences.

In summary, then, it can be stated that the four groups did not differ in the time required to read the story, nor in the time required to write their reproductions of the story. Thus, it can be assumed that these two variables did not appreciably affect one of the crucial dependent variables in the current study - recall.

Recall as a Function of Sex

Although sex was not an experimental variable under investigation, for interest's sake subjects were ordered into one of two groups on the basis of their sex, and mean CW recall scores were calculated. The means for males and females at both recall intervals are presented in Table 37.

Table 37

Mean CW Recall Scores for Males and Females at Immediate and Delayed Recall

Sex	Immediate	Delayed
Male	97.14	97.42
Female	87.62	82.38

Inspection of Table 37 shows two interesting findings: (1) the males demonstrated superior recall at both recall intervals; (2) the females showed a retention decrement at delayed recall whereas the males maintained the same recall level. To determine if these differences were statistically significant, a two-way analysis of variance employing

unequal cell frequencies with the least-squares solution was carried out for the CW recall scores. A summary of this analysis, in which the main effects were sex and recall interval, appears in Table 38. None of the F ratios was significant which indicates that the variation in recall scores between the sexes was not significant and that differences over recall interval did not reach significant levels. In addition, the interaction between sex and recall interval was not significant. Thus, although the females manifested a retention decrement at delayed recall in contradistinction with the males who sustained their higher recall scores, the minimal nature of the differences precluded a significant finding.

Table 38

Two-Way Analysis of Variance of CW Recall Scores With Sex and Recall Interval as Main Effects

Source	df	Mean Square	F Ratio
Sex (S)	1	2,167.93	0.59
Error (s)	12	3,685.45	
Recall Interval (R)	1	92.57	1.85
SR	1	83.59	1.67
Error (r)	26	50.00	

CHAPTER IV

DISCUSSION

The present investigation had as its major purpose the assessment of the effects of degree of arousal, as well as those of time of arousal, on immediate and delayed recall of connected, meaningful material. The relevance of the findings - psychological, physiological, and phenomenological - which resulted from this investigation can best be discussed as they relate to the experimental hypotheses and expectations.

Hypothesis I

It was hypothesized that the Rapid Discrimination Test (RDT) would produce a significant increase in arousal as reflected in changes in HR and/or BR. As far as HR changes during RDT were concerned, Hypothesis I was upheld in one instance, that in which the RDT was presented immediately after the story. As was mentioned earlier, as far as BR was concerned, Hypothesis I as originally stated could not be directly tested since it was not possible to establish reliable basal BR scores from which to measure recorded changes. Instead, a multiplicative breathing measure (BR x DB) incorporating rate as well as amplitude of breathing was employed. When BR x DB changes which occurred during RDT administration were analyzed, Hypothesis I was again upheld in one instance, although in this case it was not that in which the RDT was presented immediately after the story, but rather when it was presented immediately before recall.

Taking into consideration the above two findings, a tentative conclusion could be drawn to the effect that the RDT increases arousal as reflected in HR changes when it is presented immediately after the story and increases arousal as reflected in BR x DB changes when it is presented immediately before recall. It should be pointed out, however, that the analysis of variance carried out for the HR changes during RDT shown by the Pre-Recall and Control groups produced an F ratio for the main effect, arousal, of 3.17. The critical value required for a significant difference in HR change between these two groups at the 0.10 level is 3.18. It could be conjectured, then, that sizable individual differences in HR change, rather than failure on the part of RDT to produce differential arousal effects, precluded the establishment of a significant difference in HR change between the Pre-Recall and Control groups. Inspection of Appendix F tends to corroborate this contention: S_{26}, for example, with HR changes of 27, 33, and 30 during RDT, contributed considerably more to the error variance than did any one other S in the Pre-Recall group wherein the range of mean HR change during RDT was 3 to 30.

The source of such wide variability in HR change, in part, can be attributed to the operation of the principle(s) of individual response specificity and/or stimulus specificity. That is, for those Ss who manifested little change in HR, cardiac activity may well have been a much less sensitive indicant of arousal than it was for those Ss who showed marked changes in HR. In addition to, or perhaps in interaction with, this posited operation of the principle of response specificity is that of stimulus specificity. If, as proposed by Lazarus (1966, p. 376) each

kind of threat produces its own characteristic pattern of physiological response, and if it can be assumed that the RDT situation was perceived by the individuals participating in this study as threatening, but in different ways and to varying degrees because of personality differences, then it seems reasonable to propose that wide differences in HR changes were due, in part at least, to the operation of the principle of stimulus specificity.

Further, it can be conjectured that, in addition to the possible role played by personality variables as they related to the perception of the RDT as a threatening situation, personality differences possibly may have contributed to the large intra-group variance in other ways. For example, McLean (1968) found that personality-derived arousal (introversion - extraversion) and experimentally induced arousal (white noise) were additive in their effects. Even though Ss in the current investigation were randomly assigned to the conditions, it is possible, in view of the relatively small number of Ss per condition, that introverts and extraverts were not evenly distributed across the four groups. Thus, knowing where the Ss lay on the introversion - extraversion continuum might have precluded the large intra-group variance which obtained when HR changes during the administration of RDT to the Control and Pre-Recall groups were analyzed.

The above considerations regarding possible sources of error variance notwithstanding, the suggestion remained that the RDT produces heightened arousal (when arousal is defined in terms of HR change) when the task follows rather than precedes the input of verbal information, since it was in the Post-Story group that a statistically significant difference in HR change was found and the Pre-Recall group in which

important differences were noted. Although procedural differences, as well as the monitoring of different physiological indicants of arousal, prohibits direct comparison between the results of the present study and earlier research in which the RDT was found to be an arousal producing task, the findings herein presented are consistent with those of Malmo and his associates (1951a, 1951b). Especially are the findings regarding RDT presentation after information input (the story) compatible with the research of Malmo et al. wherein the RDT was administered following a Pain-Stress test. Not that the administration of pain through the use of a thermal stimulator, as described by Malmo and Shagass (1949), can be equated with or even considered an analogue of, the reading of a story, both the experiencing of pain and the reading of a story result in increased sensory input to the organism. As a result, there is an increase in number of afferent impulses conveyed by classic pathways to the brain stem which in turn produces a concomitant increase, via collaterals to the reticular formation, in the activity of the Ascending Reticular Activating System (ARAS) originally outlined by Moruzzi and Magoun (1949). The role that ARAS plays in arousal has been clearly delineated by Lindsley (1960), Magoun (1964), and others, as has also that of the descending reticular facilitating system. Of interest to the current study is that subsequent to the increased activity in the ARAS initiated by the sensory stimulation of reading the story or taking the Pain-Stress test, there is additional neuronal activity of the ARAS instituted by impulses carried by the descending reticular facilitating system. In other words, impulses originally emanating from the reticular formation, in turn, are transmitted back

to the cortex to complete the feedback circuit involved in arousal in response to specific stimuli such as those resulting from the reading of a story or the experiencing of pain. The operation of such a feedback principle is not inconsistent with Hebb's (1949) concept of reverberating neural circuits embraced by Walker (1958) in his theory of perseverative consolidation.

Thus, as a result of the original stimulation, be it that of reading or experiencing mild pain, there is a reverberation over time of impulses generated by that stimulation. Since the Post-Story group was the only one which showed a significant increase in arousal (HR change) during RDT, it is proposed that the arousal producing effects of the RDT were due, in part, to the fact that the reverberating activity in the Central Nervous System (CNS), which originated with information input (story) was sufficiently increased by sensory input resulting from the RDT, which immediately followed it, to produce a significant increase in arousal (HR change). This explanation of the significant arousal effects of RDT in the Post-Story group can be extended to provide another possible reason for the Pre-Recall's failure to show significant arousal effects although there were marked HR changes. To this group the RDT was administered after the story, but not immediately as was the case with the Post-Story group. The additional time lag of three and one-half minutes in all likelihood allowed for considerable dissipation of reverberation and thereby decreased the probability that the additional input generated by the RDT would be sufficient to significantly increase arousal. Needless to say, the explanation of heightened arousal being due to an additive function between information input and RDT presentation provided a possible

reason for the failure of Hypothesis I to be upheld in the case of Pre-Story HR change during RDT.

It should be pointed out that the above explanation of increased CNS arousal was in no way positing a direct relationship between increased CNS arousal and increased arousal as reflected in HR change. Rather it should be viewed within Malmo's (1959) general activation concept. In addition, the above explanation should not be construed as throwing any doubt on the validity of the RDT as a stress test reported by Malmo et al. or on the results of the singular presentation of the RDT reported by Smith (1969) in which a significant drop in the number of circulating lymphocytes was established. The results of the current study, especially those pertaining to HR change in the Pre-Story group (which group can be directly compared with that in which the RDT was singularly presented), merely indicated that the RDT, when presented before information input, was not sufficiently arousing to produce significant changes in HR. It could well be that lymphocyte count is a more sensitive measure of RDT-produced arousal than is HR.

This suggests one possible reason for the failure of Hypothesis I to be upheld, with the exception of the Pre-Recall group, in the case of BR x DB measures of arousal. That is, changes in breathing were less sensitive indicants of arousal than were HR changes. Another possible reason, already discussed in relation to HR changes during RDT, is the operation of the principle of stimulus specificity, as well as that of personality variables in contributing to large error variances. Perhaps of singular importance in any consideration of BR x DB change, however, was the question of the validity and reliability of these

measures. Movement artifacts made for difficult scoring, especially of the amplitude measures (DB) which were affected each time the S made a response to the RDT or moved otherwise.

An important consideration regarding the fact that Hypothesis I was not upheld in cases of HR change is that of the effect of apparatus variables. The applying of electrodes, in itself, was highly arousing for many Ss as evidenced during the pre-experimental preparation period by their spontaneous remarks to the effect that they expected to receive some sort of electrical shock. Information conveyed to them at that time regarding the purpose of the electrodes failed to dispel those fears completely as evidenced in comments made by Ss in post-experimental interviews. Since it is a well documented finding (See Lazarus, 1966) that it is the threat of shock, rather than the physical stimulus itself, which is conducive to heightened arousal, it can be conjectured that those Ss who thought that they would receive shock sometime during the experiment would show increased arousal. Further research in which such specific fears are objectively measured is necessary to support such a contention. However, some support is provided for the apparatus effect by the increased arousal, as reflected in HR and Br x DB changes, manifested by the Control group during the periods of time RDT was being presented to the treatment groups. In other words, the experimental situation, itself, without presentation of RDT was arousing. Although it was the arousal increase witnessed in the Control group which drew attention to the possible operation of apparatus effects, these effects were not exclusive to the Control group. Rather, depending on how each S perceived the experimental situation, they contributed to the error variance which may well have precluded the

general upholding of Hypothesis I.

Hypothesis II

It was hypothesized that material presented during increased arousal conditions would show poorer immediate recall and stronger delayed recall than would material presented under neutral conditions. Hypothesis II was not confirmed which was not a surprising finding in view of the fact that Hypothesis I, on which it hinged, was not consistently upheld. Since the RDT did not produce significant arousal increases in the Pre-Story as reflected in HR and BR x DB change, nor in the Pre-Recall condition in terms of HR change, nor Post-Story in terms of BR x DB change, two-thirds of the Ss in the "increased arousal conditions" did not demonstrate a significant arousal increase whether the indicant of arousal was HR or BR x DB. Therefore, it was highly unlikely that the "increased arousal conditions" would affect immediate or delayed recall in any significant way.

In addition to the partial failure on the part of RDT to produce increased arousal, there is another reason for the fact that Hypothesis II was not upheld. As was presented when Hypotheses III and IV were put to test, the RDT differentiated between the Post-Story and other three groups as well as between the Pre-Recaall and the other groups in terms of recall scores. It will be recalled that the Post-Story group had the lowest scores whereas the Pre-Recall had the highest. To test Hypothesis II, however, scores from all three treatment groups were combined. The relatively high scores obtained by the Pre-Recall group cancelled the effect of the relatively low Post-Story scores, and the scores of the Pre-Story group and those of the controls were

essentially the same. The latter finding was not surprising in view of the fact that it was the Pre-Story group who did not show a significant increase in HR nor in BR x DB during RDT administration.

Hypothesis III and IV

It was hypothesized (Hypothesis III) that material whose presentation is immediately followed by increased arousal conditions would show poorer immediate and delayed recall than material preceded by increased arousal conditions, material whose recall is preceded by increased arousal conditions, or material presented under neutral conditions. That is, it was expected that the group to whom the RDT was presented immediately after the story would show lower recall scores than would the other three groups. It was also hypothesized (Hypothesis IV) that material whose recall was immediately preceded by increased arousal conditions would show better immediate and delayed recall than would material preceded or followed by increased arousal conditions or material presented under neutral conditions. That is, it was expected that the Pre-Recall group would produce higher recall scores than would the other three groups. Hypotheses III and IV were not upheld by the results of the analysis of variance of the CW recall scores. When *a priori* comparisons of total recall (CW) scores were conducted, however, both hypotheses were confirmed.

That Hypothesis III was upheld corroborates the expectation regarding the possible disruption of the consolidating process due to the administration of RDT immediately after the story was read. Interestingly enough, this finding lends support to the interference theory of forgetting without detracting from the perseverative consolidation theory

of remembering, thereby showing that these two theories are not mutually exclusive. In particular, the confirmation of Hypothesis III adds weight to the theoretical stand first taken by Muller and Pilzecker (1900) who argued that the neural correlates of learning persist through time after active involvement in the learning situation ceases and that other activity introduced immediately after learning interferes with the consolidation process and results in a retention decrement. According to their theory, interpolated activity becomes less detrimental as the specific intervening tasks are inserted after increasing intervals of time.

> Walker (1958) similarly stated that, "one would expect demonstrable differences in perseverative consolidation as a function of the interval between ... training and the interruption.

However, in the current investigation, not only did the interpolated activity (RDT) prove disrupting (as reflected in significantly lower recall scores in the Post-Story group), it proved to be not "less detrimental" after an interval of time (3-5 minutes), but rather produced increments in retention (as reflected in significantly higher recall scores in the Pre-Story group). Thus, although retroactive interference on the part of the interpolated RDT provides a theoretical construct with which to explain the confirmation of Hypothesis III, it is an inadequate theoretical formulation as far as any explication of the confirmation of Hypothesis IV is concerned. In addition to the fact that the RDT was an interpolated task for the Post-Story and Pre-Recall groups, its arousal producing qualities need to be taken into consideration.

The terms, arousal and stress, are often used interchangeably,

although, depending on the conceptual framework in which they are being employed, they need not be synonymous. Solley, reported by Rourke (1969) said this of stress:

> It is a two-edged sword, and it is not pecular that it can cut two ways. Much depends on how much and how long the stress is applied to the organism.

Since Solley's definition of a stressful situation (that which "puts pressure on the individual to perform more accurately or faster or differently from his normal mode"), inadvertently describes the arousal producing agent herein, employed (RDT) his remarks become particularly cogent. The RDT was a "two-edged sword": it disrupted recall when it came immediately after the story; it facilitated recall when it came immediately prior to recall. Here, however, it was not so much the case of how much and/or how long the stress was applied; rather it was a question of when it was applied.

One explanation of the RDT's facilitative effect on recall when its temporal placement was immediately adjacent to the recall period is that proposed by Malmo's activation hypothesis. That is, the RDT increased arousal (activation) to a level which was "moderate" thereby producing "optimal" performance on the recall test. This explanation is similar to that proferred in Chapter I as an alternative to Bourne's interpretation of the results of his investigation of the effects of muscular tension on recall. In addition to other procedural differences between that study and the present investigation, however, is the critical temporal factor. Bourne was investigating tension (which was herein interpreted as increased arousal) during recall, whereas the effects under consideration here are those of arousal before recall.

Since additional analyses of arousal changes (HR and BR x DB) which occurred during immediate recall indicated that the groups were not significantly differentially aroused at that time (See Tables 30 and 31), it seemed reasonable to conclude that the higher recall scores which obtained in the Pre-Recall group were due to the temporal continguity between RDT and recall period.

In line with predictions from Walker's (1958) consolidation theory, however, it could be argued that it was the heightened arousal shown by the Pre-Recall group during the story (See Figures 12 and 13) which contributed to their higher recall scores. If such were the case, however, an increment in delayed recall, rather than the decrement as shown in Table 11, would have been expected. To insure that arousal differences during the story were not critical factors in the significantly higher recall scores of Pre-Recall Ss, nor in the significantly lower scores of Post-Story Ss, arousal measures taken during the story were subjected to analyses (See Tables 27 and 28), the results of which indicated that differences in arousal were not significant.

That the significant increases in arousal during RDT administration to the Post-Story and Pre-Recall groups contributed to the significant findings which confirmed Hypotheses III and IV, there was little question. In those two instances the RDT served its purpose well. It should be pointed out, however, that arousal changes shown by these two groups were significantly different from those shown by the Control group and not from each other or Pre-Story as subsequent analyses indicated (See Tables 25 and 26). Thus, it was not differential arousal as shown by either HR or BR x DB in the Post-Story or Pre-Recall group which effected the signifi-

cantly lower recall scores of the former and the significantly higher recall scores of the latter. Once again it can be stated that the crucial factor in the confirmation of Hypotheses III and IV was that of the temporal contiguity of the story and RDT (Hypothesis III), and RDT and the recall period (Hypothesis IV).

Since there has been suggested a relationship between reading rate and retention (Thalberg, 1967), it seemed wise to examine reading time (RT) scores to determine if they had any bearing on the outcome of tests of Hypotheses III and IV. Although Post-Story had the fastest mean RT (see Table 32), analysis of variance of RT scores failed to show any statistically significant differences between the groups. It appeared, then, that reading rate did not affect the recall scores. Further support for this contention was provided by the outcome of a chi-square test of contingencies which obtained between reading rate and recall scores. Results of this test indicated that reading rates and recall scores were independent in the sample (see Table 33). This was the case for both immediate and delayed recall scores. Therefore, it seemed reasonable to conclude that reading rate was not a critical variable in the outcome of tests of Hypotheses III and IV.

As far as memory time (MT) measures were concerned, Post-Story required the shortest time in which to write recalls. This was not a surprising finding in view of the fact that it was this group which had the lowest recall scores. Stated simply, it took less time to write less. An analysis of variance of MT scores for all groups failed to show significant differences between the groups. Therefore, it seemed reasonable to conclude that MT was not a critical variable in affecting the outcome of

tests of Hypotheses III and IV which confirmed the predictions that material whose presentation is immediately followed by increased arousal conditions would show poorer immediate and delayed recall than would material presented according to the other three procedures and that material whose recall is immediately preceded by increased arousal conditions would show better recall than that shown in the other three groups.

That Hypothesis III was upheld is in disagreement with Levonian's (1967) findings which suggested that the effects of arousal on recall are the same regardless of whether the arousal precedes or follows information presentation. In Levonian's study, however, the mediator of arousal could not be identified, whereas it was mediated by a specific interpolated task (RDT) in the Post-Story and Pre-Recall groups in the current investigation. The confirmation of Hypothesis III is also at variance with findings reported by Berlyne et al. (1966) which indicated that arousal (white noise) after stimulus and response does not affect immediate or delayed recall. It should be borne in mind, however, that wide procedural differences precluded the drawing of any direct comparisons between the results of the present study and those of Levonian and Berlyne et al. Therefore, doubt is not cast on their findings, nor on those herein presented. Rather, it can be concluded that the effects of arousal immediately after the presentation of to-be-remembered material depend, in part at least, on the nature of the mediator of arousal.

The confirmation of Hypotheses III and IV provided an answer to one of the major questions posed by the current study regarding whether the placement of the mediator of arousal at different points in the

learning-recall sequence would differentially affect recall. It appeared that placement of the arousal-producing agent (RDT) did differentially affect recall. When it was placed immediately after the story it impaired recall, whereas its placement immediately before recall enhanced recall. This suggests that there are distinct memory processes (e.g., storage and retrieval) and that these processes are differentially affected by arousal as produced by RDT.

Hypothesis V

It was hypothesized that material presented during "high" arousal would show poorer immediate recall and stronger delayed recall than would material presented under "low" arousal. Hypothesis V was not upheld. Rather than showing impairment at IR and enhancement at DR, the high arousal (HA) group, compared with the low (LA), demonstrated better recall at both recall intervals. Such a finding at IR provided support for Malmo's (1959) activation - expected performance paradigm concerning the relationship between low arousal and low performance, and moderate arousal and optimal performance. As was presented earlier (see p. 24), however, Malmo's activation hypothesis does not include predictions regarding the relationship between arousal level and delayed recall. Perseverative consolidation theory, on the other hand, embraces predictions about both immediate and delayed recall performance. On the surface of it, the results of the testing of Hypothesis V would indicate that such predictions were herein refuted.

Failure to uphold Hypothesis V, however, does not necessarily indicate that the general hypothesis which predicts an interaction between arousal and recall interval is not tenable. The fact that HA

did not show a recall decrement at DR, whereas LA recall scores reflected a five per cent loss over the twenty-four hour period, suggested, although only slightly, that there was a tendency towards forgetting on the part of LA Ss. Reminiscence was not manifested by HA Ss, but they did not show the traditional recall decrement over time. Thus, although the differential affect of arousal at IR and DR was not sufficiently great enough to produce a significant interaction, the effects were more marked at DR than they were at IR. And it should be pointed out that, with the exception of Kleinsmith and Kaplan's (1963, 1964) studies, the critical differences in recall between HA and LA groups have been those which obtained at DR. To determine whether there is a trend towards greater differences at DR as suggested by the present results, further research is required in which another recall interval (perhaps one week) is also employed so that the direction of the results could be ascertained. It could be speculated that the outcome of such a test would show even greater differences between the recalls of HA and LA.

Although the differences between HA and LA recall scores at DR are consistent with predictions from perseverative consolidation theory, the superior recall shown by HA at IR is not. As presented above, this finding can be explained in terms of Malmo's activation hypothesis. It could also be argued, however, that the IR test employed in the current investigation, because of its temporal placement (7 minutes after the end of the story presentation), was not an immediate test of recall in the strictest sense of the term. Walker (1958) proposed that a perseverative trace process is set into motion with the occurrence of any psychological event and that the process gradually establishes permanent memory

at the expense of immediate memory by protecting the consolidating trace from immediate interference. The perseverative nature of the hypothesized trace process raised a critical question which is particularly pertinent to the results of the IR test shown by HA and LA: How long was it before the perseveration of traces produced by the reading of the story became dissipated? From a neuropsychological point of view the duration of reverberation as originally postulated by Hebb (1949, p. 143) was estimated at about half a second for a single "cell assembly," and a few seconds for a "phase sequence". Cytological approaches have suggested, however, that synaptic activity can last for several minutes (Eccles, 1965). If seven minutes is considered a longer period of time than "several" minutes, however, it can be assumed that the perseveration of traces produced by reading the story were dissipated before the immediate recall period began. That consideration would allow the IR test herein employed to be considered an early DR test. Expected effects of arousal on recall at the seven minute test, considered as a DR test would be not unlike those reflected by the results of the HA and LA groups. That is, in keeping with predictions from consolidation theory, HA would show better recall than would LA.

It should be borne in mind that the above explication of the failure to uphold Hypothesis V is purely speculative. There are other reasons of a more empirical nature which can be offered in explanation of the non-tenability of Hypothesis V. Firstly, the non-discrete nature of the material to-be-remembered (story) did not allow for the ordering of "items" as was the case in those studies which demonstrated the interaction phenomenon (Kleinsmith and Kaplan, 1963, 1964; Walker and Tarte,

1963; Levonian, 1967; McLean, 1968). Rather, Ss were ordeeed into HA and LA groups. It is highly likely, however, that some parts of the story were more arousing than were others. It is recommended that further investigations of the effects of arousal on the immediate and delayed recall of connected, meaningful material devise a method whereby arousal at specific points in the material's presentation could be determined. Such a procedure would allow for something akin to the ordering of items which was precluded in the present investigation. Inspection of the actual recalls showed that certain details (which may have been differentially arousing) were included in the individual S's delayed recall whereas they had not appeared in his immediate reproduction of the story. It is possible that the ordering of details or sections of the story in terms of their arousal value may have produced results which would have confirmed Hypothesis V.

Secondly, Hypothesis V was generated from a survey of research findings in which the retention was measured by the recognition method while the recall (reproduction) method was herein employed. The only pertinent study in which both methods (recognition and recall) were utilized was that conducted by Williams and Frinke (1968). As previously pointed out, their investigation did not include any monitoring of physiological indicants of arousal; however, those Ss who presumably were aroused showed impairment at IR but enhancement at DR, with the controls showing the opposite, when the retention test was one of recognition. When the recall method was employed, no differences in recall were in evidence. The fact that differential treatment relationships obtained when retention was measured by recognition rather than

by recall prompted Williams and Frinke (1968, p. 276) to suggest that:

> . . . the kind of learning tapped by recall and recognition may not be identical, or that retrieval processes involved in the two types of performance are different, or both.

Their suggestion notwithstanding, the results of their study could also be interpreted to mean that arousal differentially affects immediate and delayed recall depending on the retention test method employed.

The findings of the present investigation as they apply to Hypothesis V stand approximately mid-way between those of Williams and Frinke, in which no differences were found when the recall method was employed, and those cited above in which the interaction between arousal and recall interval was demonstrated when the recognition method was used. This may not be mere coincidence since the reproduction (recall) of connected, meaningful material, in a sense, uses a combination of the two methods (recall and recognition). As the S began writing his reproduction, it was a case of unaided recall, but once having completed the first part of it, he had before him stimuli which could elicit, through association, additional details of the story. Therefore, the failure to uphold Hypothesis V, need not be construed as a failure to demonstrate the interaction phenomenon in which arousal differentially affects immediate and delayed recall. Rather, the phenomenon may have been obscured because of the differential effects of arousal on recall and recognition.

Lastly, it could be argued that the use of a repeated measures design contributed to the negative findings related to Hypothesis V, since it has been shown that an immediate recall of connected, meaningful material increases the accuracy of a delayed recall (Clark, 1940;

King and Cofer, 1960; Lana and King, 1960). Be that as it may, the crucial point as far as the results under consideration were concerned indicated that, if accuracy of DR was increased by IR, it was not increased to the same extent in both HA and LA conditions. Thus, although no significant interaction was demonstrated, the findings regarding impairment at DR for the LA group provided some support for predictions from perseverative consolidation theory which were incorporated in Hypothesis V.

Expectation 1

It was expected that those Ss who showed cardiac deceleration during the experiment would recollect that they had felt more accepting than those Ss who showed cardiac acceleration. Expectation 1 was not confirmed, but the results at IR were in the predicted direction. That is, decelerates had higher accepting scores than did the accelerates. On the presentation of the RRS at DR, however, there was a modification in the recollected feelings of acceptance shown by the decelerates which indicated that, in retrospect, they recollected that they had felt less accepting than their earlier recollections at IR had indicated. This finding suggested that there was a tendency for feelings of acceptance of the experimental situation to be differentially appraised over time. This could be interpreted to mean that individuals who are initially more accepting of a situation are also more likely to change their assessment of their feelings towards that situation at a later time. In other words, those who are quick to accept are also quick to later reject.

Although Expectation 1 was not confirmed, the direction of the

results, especially at IR, lend some support to the proposal put forth by Lacey et al. (1963) regarding the relationship between direction of heart rate change and acceptance of environment. Failure to confirm Expectation 1 could be partially due to the fact that the RRS did not allow for the recording of recollected feelings as they pertained to different aspects of the experiment. For example, a S may have felt accepting or rejecting to a different degree depending on which part of the experiment - preparation period in which the electrodes were applied, periods of "solitary confinement" in the experimental room, RDT presentation, story reading, or recall - came to mind as he was recollecting his feelings about the experiment. Furthermore, feelings at one of these times could have been modified by other feelings at other times during the experiment. If, for example, a S had felt particularly rejecting towards the RDT, but accepting towards the story, the effects of the latter might have cancelled, or at least modified, the former. Thus, the magnitude of the scale (Accepting - Rejecting) ratings could have been considerably depressed resulting in a relatively narrow range of scores and thereby precluding significant differences.

Expectations 2 and 3

It was expected that those Ss exposed to the RDT during the experiment would recollect that they had felt less comprehending than would the control Ss to whom the RDT was not administered. Expectation 2 was confirmed which could be interpreted to mean that lack of comprehension felt by the treatment groups resulted from the absence of any intrinsic connection between the two experimental tasks of judging circle size and reading a story.

Expectation 3 which predicted that Ss presented with the RDT would recollect that they felt more aroused than would the controls was not confirmed. As expected, the treatment Ss were more aroused according to their recollections than were the controls, but the differences were not sufficiently large enough to produce statistical significance. That Expectation 3 was not confirmed is in keeping with the fact that Hypothesis I, which predicted arousal increases in all treatment groups, was not upheld in all cases. Failure to confirm Expectation 3, then, need not be construed as a negative finding. Rather, the results suggested a positive correlation between physiological and phenomenological indices of arousal which is consistent with recent findings reported by Frankenhaeuser, Froberg, Hagdahl, Rissler, Bjorkvall and Wolff (1967).

Expectation 4

It was expected that those Ss who recollected that they felt more accepting during the experiment would produce better recalls than would those Ss who recollected that they felt more rejecting. Expectation 4 was not confirmed, but a finding of no little importance resulted. Contrary to predictions, the rejecting group produced superior recalls, although this situation obtained only at IR. At DR the differences had almost totally disappeared. In other words, the rejecting group showed significant forgetting, whereas the accepting group demonstrated a slight reminiscence effect. Viewed within consolidation theory framework, this outcome suggested that the accepting group were relatively more aroused than the rejecting group. An equally attractive interpretation, however, is that different attention factors were operating

in the two groups. That these two interpretations are not mutually exclusive is supported by Solley's (1969) work on stress and attention as well as Daly's (1969) speculations on the relationship between attention and arousal.

When it is borne in mind that it was not the ordering of Ss on the basis of physiological measures of arousal which produced the interaction between experimental conditions and recall interval, but the ordering of Ss in terms of their recollections regarding their feelings during the experiment, the cruciality of phenomenological adjuncts to psychological investigations becomes very apparent. The important of the phenomenological findings which resulted from the testing of Expectation 4, in general, provided additional weight to Hanfmann's (1964) conviction that more attention should be devoted to the analysis of the "inner state" of the individual. In particular, they extend support to Bartlett's (1932) contention that part and parcel of schema formation, operation, and reproduction are affective aspects of the experience.

Expectation 5

It was expected that those Ss who were ordered into the "high" arousal group on the basis of HR and/or BR x DB changes during the story would recollect that they felt more aroused than would those Ss who were ordered into the "low" arousal group. Expectation 5 was not confirmed, although there were small differences in recollected feelings of arousal in the direction predicted. This finding is in line with the outcome of tests of Hypothesis I and Expectation 3 wherein it was found that the RDT did not produce overall increases in arousal of significant magnitude and the treatment Ss did not recollect that they

felt more aroused, at a significant level, than did the controls. In other words, there were differences in arousal, as recorded physiologically, as well as phenomenologically, but they were not sufficiently great enough to produce significance. Therefore, the failure to confirm Expectation 5 was not a surprising finding.

When the ratings made by the high and low arousal groups on all four scales of the RRS at both IR and DR were subjected to analysis, however, an interesting interaction was observed. The high arousal group demonstrated an increase in both their recollections of pleased feelings and comprehending feelings, whereas the low arousal group demonstrated the reverse. In view of the fact that it was the LA group who showed the significantly lower recall scores at IR, as well as manifesting a retention loss at DR, the above interaction between feelings (of pleasure and comprehension) and recall interval was a meaningful outcome. In other words, the modifications in the pleased and comprehending feelings of the two arousal groups in part, could be reflections of their subjective assessments of their performance on the recall tests.

Implications of the Findings

Although the results herein presented and discussed are equivocal, the implications which they have for experimental as well as applied (especially educational and clinical) psychology are numerous. Those salient are: (1) Assessment of the individual's "inner state", especially as it relates to his accepting feelings, as well as those of pleasure and comprehension, is crucial to an understanding of the outcome of a procedure in which arousal is a critical variable. (2) Personality

factors, especially those which relate to the introversion - extraversion continuum, need to be taken into consideration when choosing Ss for future research in which degree of arousal is involved. (3) The temporal placement of an arousing situation has a direct bearing on the degree of change in arousal as physiologically measured as well as on that which is recalled. (4) Heart rate remains a more reliable physiological indicant of arousal than do breathing measures as guaged by a Respiration Transducer.

The importance of assessing the individual's feelings can be appreciated when the significant interaction between accepting-rejecting feelings and recall interval is borne in mind (See Tables 22 and 23). This is possibly the first demonstration of such an interaction -- an interaction which educational psychologists have long proposed.

The cruciality of assessing personality factors can be understood in terms of the large error variances which resulted in the present investigation wherein such assessment was not included. When the contribution to overall variance made by individual differences clouds the "real" differences which exist between treatment groups, personality variables must be brought under experimental control.

CHAPTER V

SUMMARY AND CONCLUSIONS

The major purpose of the present investigation was to assess the affects of degree of arousal, as well as those of time of arousal upon immediate (7 minutes) and delayed (24 hours) recall of connected, meaningful material. Four groups of undergraduates were asked to read Bartlett's (1932) story, "The War of the Ghosts" and then reproduce it at the designated times. Arousal was produced experimentally through the administration of a modified version of Belanger's (1957) Rapid Discrimination Test (RDT). The groups were originally differentiated on the basis of whether the RDT was presented immediately before the story (Pre-Story), immediately after (Post-Story), immediately before recall (Pre-Recall) or not al all (Control). Heart rate (HR) and a multiplicative measure combining respiration rate and amplitude (BR x DB) were the physiological indicants of arousal employed. Recalls were scored for content words used in the original version of the story.

A survey of the theoretical and empirical literature led to the proposal of the following hypotheses:

Hypothesis I. The RDT will produce a significant increase in arousal as reflected in HR and/or BR.

Hypothesis II Material presented during increased arousal conditions will show poorer immediate recall and stronger delayed recall than will material presented under neutral conditions.

Hypothesis III Material whose presentation is immediately followed by increased arousal conditions will show poorer immediate and delayed recall than material preceded by increased arousal conditions, material whose recall is preceded by increased arousal conditions, or material presented under neutral conditions.

Hypothesis IV Material whose recall is immediately preceded by increased arousal conditions will show better immediate and delayed recall than material whose presentation was either preceded or followed by increased arousal conditions, or material presented under neutral conditions.

Hypothesis V Material presented under "high" arousal will show poorer immediate recall and better delayed recall than material presented under "low" arousal.

With respect to these hypotheses, the results of the study indicated the following: Hypothesis I was upheld in the case of HR changes as shown by the Post-Story group, and in the case of BR x DB changes as manifested by the Pre-Recall group; in all other instances Hypothesis I was rejected; Hypothesis II was rejected; Hypothesis III was upheld; Hypothesis IV was upheld; Hypothesis V was rejected, but the results bearing upon this hypothesis suggested a trend in the predicted direction.

The rejection of Hypothesis II was discussed in relation to the adequacy of the RDT as an arousal producing agent for purposes of demonstrating the interaction between increased arousal conditions and immediate and delayed recall. That Hypothesis I was only upheld in two instances out of six indicated that the RDT was not a completely adequate mediator of arousal for such purposes. The rejection of

Hypothesis I in four instances was discussed in terms of individual differences in physiological responsivity and the contributions possibly made to those differences by such things as the threat value of the experimental situation, and personality variables. In addition, the time of arousal; i.e., the time of RDT administration was discussed in a physiological context in terms of its relevance to the partial rejection of Hypothesis I. The validity and reliability of the multiplicative breathing measure (BR x DB) were questioned. As physiological indicants of arousal they possibly provided inadequate data for the testing of Hypothesis I.

The significance of additional findings concerning differences in reading time and memory time as well as those of arousal changes shown during RDT, story, and recall were discussed in terms of their relevance to the confirmation of Hypotheses III and IV. That Hypothesis III was upheld was discussed within the framework of perseverative consolidation theory as well as that of interference. Malmo's (1959) activation hypothesis was supported by the confirmation of Hypothesis IV. The upholding of both Hypothesis III and IV suggested that there are distinct memory processes - storage and retrieval - and that these processes are differentially affected by arousal as produced by the RDT.

Rejection of Hypothesis V was discussed in terms of the possible differential affects of arousal on immediate and delayed recall depending on the method of measuring recall - reproduction or recognition. In addition, the need for further research in which an earlier immediate test is employed as well as an additional delayed test so that the suggested trend, which was in the predicted direction, could be better

ascertained, was discussed. It was further suggested that a procedure be devised which would allow continuous presentation of the connected, meaningful material so that arousal at specific points in its presentation could be determined.

The failure to uphold Hypothesis V was not considered a refutation of the general hypothesis which tests predictions from perseverative consolidation theory. Rather, unequivocal conclusions concerning the effects of arousal on immediate and delayed recall of connected, meaningful material await future experimentation.

Ancillary expectations related to the phenomenological aspects of the current investigation also proposed were as follows:

(1) Those subjects who show cardiac deceleration (decrease in HR) will recollect that they felt more accepting during the experiment than those subjects who show cardiac acceleration (increase in HR).

(2) Those subjects exposed to the RDT will recollect that they felt less comprehending than will the controls.

(3) Those subjects exposed to the RDT will recollect that they felt more aroused than will the controls.

(4) Those subjects who recollect that they felt more accepting during the experiment will show better recall than those subjects who recollect that they felt more rejecting.

(5) Those subjects who are ordered into the "high" arousal condition on the basis of HR and/or BR changes during the story will recollect that they felt more aroused than will those subjects who are ordered into the "low" arousal condition.

These expectations were tested through analyses of the Recollection Rating Scale (RRS) data as they related to HR change, treatment groups, and recall scores. The results of the investigation

with respect to the expectations indicated that: Expectation 1 was rejected, but the results were in the predicted direction when the RRS was administered at immediate recall; Expectation 2 was confirmed; Expectation 3 was rejected, but the results bearing upon this expectation were in the predicted direction; Expectation 4 was rejected, but the results in question indicated a trend in the direction opposite to that which had been predicted; Expectation 5 was rejected, but the results were in the predicted direction.

The rejection of Expectation 1 was discussed in terms of the failure on the part of RRS to discriminate between recollections of feelings which occurred at different times during the experiment. That Expectation 3 was not confirmed was discussed in the light of failure to uphold Hypothesis I. The rejection of Expectation 4 was discussed in terms of the importance of phenomenological adjuncts to psychological investigations. Failure to uphold Expectation 5 was discussed in the light of rejection of Hypothesis I and Expectation 3.

Although it was only Expectation 2 which was confirmed, with the exception of Expectation 4, the results bearing on the other expectations were in the predicted direction. Unequivocal conclusions concerning the relationships between feeling states, physiological indices of arousal, arousal conditions and recall await the results of future research in which a more precise instrument for measuring subjective emotional experiences is employed. The equivocal nature of the present findings notwithstanding, implications for experimental and applied psychology were presented.

Appendix A

RDT Slide Presentation Order

Presentation No.	Correct Circle
1	3
2	1
3	5
4	6
5	2
6	4
7	3
8	2
9	6
10	5
11	4
12	1
13	6
14	1
15	4
16	5
17	3
18	2
19	3
20	1
21	2
22	4
23	1
24	5
25	6
26	3
27	5
28	6
29	4
30	2

Appendix B

The War of the Ghosts

One night two young men from Egulac went down to the river to hung seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought: "Maybe this is a war-party." They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men in the canoe, and they said: "What do you think? We wish to take you along. We are going up the river to make war on the people."

One of the young men said: "I have no arrows."

"Arrows are in the canoe," they said.

"I will not go along. I might be killed. My relatives do not know where I have gone. But you," he said, turning to the other, "may go with them."

So one of the young men went, but the other returned home.

And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water, and they began to fight, and many were killed. But presently the young man heard one of the warriors say: "Quick, let us go home: that Indian has been hit." Now he thought: "Oh, they are ghosts." He did not feel sick, but they said he had been shot.

So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said: "Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick."

He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried.

He was dead.

Appendix C

Name_____

M or F_____

Age_____

Group_____

Recollection Rating Scale

INSTRUCTIONS:

You will be asked to think of the experimental situation which you have just experienced and to rate it on 4 scales. The 4 ratings should show how you felt during the experience. The first rating is a measure of how pleasant the situation was. The second rating indicates how aroused you felt, how involved you were in what was going on. The third rating shows the extent to which you accepted or rejected the situation. Finally, the fourth rating tells whether you felt puzzled and "at a loss" to explain what was happening or whether you felt thoroughly comprehending and "in the know."

Each scale consists of a row of 18 numbers with a single word at each end of the row. The 2 words have opposite meanings and define the scale. Circle a single number of each scale to indicate how you felt during the experiment. By circling a low number you indicate that you felt like the word at the left end of the row, by circling a high number you indicate that you felt like the word at the right end of the row, and by circling a number of intermediate value you indicate that you felt little more like one word than like the other. In other words, you are to measure your own feelings, using 4 different 18-point scales.

If you cannot remember exactly how you felt during the experiment, just imagine how you probably felt. It is perfectly all right to guess what your feelings were like.

Now think about the experimental situation. How did you feel? Show your feelings by rating them on the following 4 scales.

PLEASED DISPLEASED

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

INDIFFERENT AROUSED

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

ACCEPTING REJECTING

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

PUZZLED COMPREHENDING

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Appendix D

Content Words

accompanied	Egulac	house	no	seals	wish
all	escaped	hunt	not	take	you
along	everybody	I	now	that	young
are	face	Indian	one	them	
arrows	feel	is	oh	there	
ashore	fell	it	other	they	
attacked	fellows	jumped	our	think	
back	fight	Kalama	paddles	this	
be	fire	killed	people	those	
became	five	know	presently	thought	
been	foggy	let	quick	told	
began	ghosts	log	quiet	town	
behold	go	made	relatives	turning	
black	going	man	returned	two	
calm	gone	many	river	us	
came	had	may	rose	war	
canoe	has	make	something	war-cries	
canoes	have	maybe	sun	war-party	
coming	he	men	said	warriors	
contorted	heard	might	say	was	
cried	hid	mouth	saw	water	
dead	hit	my	shore	we	
did	his	night	shot	what	
do	home	noise	sick	will	

Appendix E

Pre-Experimental, Mean, and Post-Experimental Basal Readings

	HR			BR x DB		
S	Pre	Mean	Post	Pre	Mean	Post
1	84	90	96	177.12	185.31	193.50
2	90	87	84	102.84	102.20	101.56
3	90	90	90	404.40	397.66	390.92
4	102	102	102	198.58	178.82	159.06
5	90	84	78	115.38	106.12	96.88
6	66	66	66	88.73	92.56	96.39
7	96	90	84	125.88	103.93	81.98
8	90	87	84	395.01	355.98	316.96
9	120	117	114	240.82	271.94	303.05
10	90	90	90	299.95	341.15	382.35
11	90	88	86	95.70	97.85	100.00
12	72	74	76	156.80	163.30	169.80
13	90	90	90	123.42	148.41	173.40
14	78	77	76	336.60	316.90	297.21
15	78	78	78	419.39	419.64	419.89
16	120	115	110	173.29	130.66	88.02
17	60	64	68	176.25	143.62	111.00
18	72	75	78	146.20	145.82	145.45
19	72	75	78	198.00	244.44	290.88
20	84	84	84	72.15	81.72	91.30
21	66	72	78	247.50	278.95	310.40
22	84	78	72	431.68	350.64	269.60
23	78	78	78	108.19	106.52	104.84
24	84	78	72	159.44	160.82	162.20
25	72	72	72	204.56	252.28	300.00
26	66	63	60	134.24	151.84	169.45
27	84	87	90	128.15	171.53	214.91
28	84	81	78	189.66	178.73	167.80

Appendix F

Group	S	Arousal During RDT (HR) Base	Beginning	Mid-Point	End
$Control_1$	1	90	96	90	96
	2	87	84	90	84
	3	90	96	90	90
	4	102	108	108	96
	5	84	84	87	84
	6	66	66	66	66
	7	90	96	96	96
$Control_2$	1	90	84	90	84
	2	87	96	96	90
	3	90	102	90	90
	4	102	102	102	96
	5	84	87	84	84
	6	66	72	66	66
	7	90	96	90	96
$Control_3$	1	90	102	90	90
	2	87	87	90	90
	3	90	96	96	96
	4	102	96	96	96
	5	84	90	84	84
	6	66	60	78	72
	7	90	96	90	90
Pre-Story	8	87	84	78	78
	9	117	126	120	120
	10	90	90	90	90
	11	88	84	90	84
	12	74	66	72	72
	13	90	102	102	96
	14	77	96	90	90
Post-Story	15	78	96	90	78
	16	115	126	132	120
	17	64	70	72	72
	18	75	78	90	90
	19	75	78	78	72
	20	84	78	78	72
	21	72	72	78	78
Pre-Recall	22	78	84	84	84
	23	78	78	81	72
	24	78	78	78	84
	25	72	84	75	78
	26	63	90	96	93
	27	87	96	108	96
	28	81	96	105	93

Group	S	Arousal During RDT (BR x DB) Base	Beginning	Mid-Point	End
$Control_1$	1	185.31	155.04	160.81	161.04
	2	102.20	87.35	122.94	101.04
	3	397.66	458.22	396.27	412.80
	4	178.82	186.96	60.97	203.48
	5	106.12	178.50	200.00	350.00
	6	92.56	72.15	80.00	80.28
	7	103.93	133.29	109.78	161.10
Pre-Story	8	355.98	248.71	292.60	328.95
	9	271.94	270.94	213.36	200.00
	10	341.15	238.14	305.04	238.00
	11	97.85	227.76	277.35	247.95
	12	163.30	58.05	100.00	200.04
	13	148.41	241.88	315.34	196.38
	14	316.90	330.88	307.91	285.21
$Control_2$	1	185.31	242.07	224.89	139.96
	2	102.20	90.85	164.71	124.36
	3	397.66	341.51	300.04	311.30
	4	178.82	184.60	119.97	100.62
	5	106.12	276.56	216.71	100.80
	6	92.56	74.96	60.69	66.26
	7	103.93	113.54	156.46	136.79
Post-Story	15	419.64	516.45	541.62	397.39
	16	130.66	119.99	117.40	220.00
	17	143.62	180.00	118.52	102.08
	18	145.82	189.48	197.11	238.28
	19	244.44	122.55	206.85	167.48
	20	81.72	98.35	470.00	400.00
	21	278.95	88.52	270.90	179.16
$Control_3$	1	185.31	154.53	259.61	215.32
	2	102.20	93.31	101.27	74.98
	3	397.66	266.64	281.51	335.00
	4	178.82	117.81	138.46	133.76
	5	106.12	187.50	163.91	98.09
	6	92.56	54.56	89.66	77.34
	7	103.93	76.34	96.53	121.88
Pre-Recall	22	350.64	433.67	188.54	586.30
	23	106.52	111.14	168.49	87.08
	24	160.82	39.36	62.14	191.82
	25	252.28	258.38	368.10	211.80
	26	151.84	210.00	250.00	249.90
	27	171.53	150.00	280.44	217.50
	28	178.73	430.32	250.05	280.43

Arousal During Story

Group	S	HR Change Begin	HR Change Mid	HR Change End	BR x DB Change Begin	BR x DB Change Mid	BR x DB Change End
Control	1	-12*	- 6	0	- 40.73	- 88.45	- 10.92
	2	3	3	3	- 29.42	33.84	9.95
	3	6	0	6	179.94	60.35	139.76
	4	- 3	- 6	- 6	12.90	- 7.44	23.45
	5	0	0	0	166.31	145.29	223.88
	6	0	0	0	13.77	10.56	- 10.06
	7	15	6	6	41.76	41.38	73.33
Pre-Story	8	- 3	3	9	- 56.12	203.88	39.03
	9	3	3	- 3	70.08	13.42	-114.93
	10	0	0	0	- 84.05	- 74.93	13.09
	11	-16	-10	-10	- 30.64	- 34.31	- 41.93
	12	- 2	4	- 2	-114.14	- 93.74	- 80.23
	13	6	6	6	- 10.36	26.94	100.63
	14	13	7	26	- 89.54	- 8.38	- 31.90
Post-Story	15	0	0	0	-128.64	110.67	63.52
	16	17	17	11	- 53.53	6.46	12.72
	17	8	2	2	40.94	54.38	- 8.53
	18	9	9	15	-172.93	75.45	65.27
	19	6	9	3	- 73.04	- 16.96	- 8.44
	20	- 3	0	- 6	- 42.03	- 23.38	- 53.94
	21	6	0	6	2.66	- 13.36	20.93
Pre-Recall	22	9	3	0	63.62	37.18	-154.66
	23	18	6	12	164.74	79.69	50.64
	24	9	6	0	-122.95	8.98	6.86
	25	6	0	0	- 86.76	- 12.93	- 51.28
	26	15	9	9	156.68	83.57	21.32
	27	21	6	15	71.51	202.48	439.52
	28	12	9	3	- 58.75	21.27	27.52

* Values Represent a Decrease From Base

Arousal During Immediate Recall

Group	S	HR Change Begin	HR Change Mid	HR Change End	BR x DB Change Begin	BR x DB Change Mid	BR x DB Change End
Control	1	-12	0	-12	- 53.64	-107.53	11.70
	2	9	9	6	66.98	197.81	131.50
	3	12	12	6	293.09	495.45	297.72
	4	6	0	0	73.00	125.08	67.34
	5	6	12	6	265.45	300.85	328.01
	6	6	18	0	73.24	50.24	32.44
	7	12	12	9	21.07	- 59.27	- 3.94
Pre-Story	8	3	9	15	- 46.22	-115.98	134.88
	9	3	- 3	3	42.22	182.36	300.01
	10	15	6	- 6	52.81	49.70	83.51
	11	2	2	8	- 16.04	17.55	- 3.41
	12	13	4	4	-111.88	-109.57	- 88.25
	13	15	12	12	- 31.05	29.59	91.66
	14	7	7	7	- 59.08	-155.97	- 84.07
Post-Story	15	21	6	0	63.15	159.48	- 40.68
	16	11	2	5	77.06	110.66	103.72
	17	14	8	8	15.24	- 12.94	- 31.12
	18	9	3	9	54.22	118.18	23.18
	19	3	9	3	21.10	- 89.91	-100.25
	20	12	0	0	218.17	377.12	231.24
	21	6	12	18	-180.39	- 90.71	- 64.58
Pre-Recall	22	0	0	6	-244.76	157.63	- 71.54
	23	6	6	12	106.33	- 26.16	172.48
	24	6	0	6	- 1.44	- 77.61	- 88.12
	25	6	0	0	65.24	175.16	3.43
	26	15	9	12	- 86.68	50.96	6.04
	27	21	9	15	- 67.49	40.54	- 40.78
	28	15	9	9	112.49	- 4.83	46.29

Appendix G

Recall Scores

S	Sex	Immediate Recall				Delayed Recall			
		CW	WP	WM	WO	CW	WP	WM	WO
1	M	150	285	131	82	154	286	139	82
2	M	102	229	83	51	104	277	86	52
3	F	92	154	87	53	87	162	79	47
4	F	80	188	66	39	70	188	57	34
5	F	64	111	61	39	60	128	58	38
6	M	80	138	68	40	72	141	62	40
7	F	60	116	57	40	74	153	67	40
8	M	118	203	115	71	125	214	123	72
9	F	115	215	99	56	107	214	95	53
10	F	80	173	74	46	76	173	70	40
11	M	47	127	44	28	54	140	41	27
12	M	57	108	54	33	65	137	59	36
13	F	76	150	68	34	66	152	57	38
14	F	147	250	128	73	146	248	133	76
15	F	49	110	46	28	34	125	30	20
16	M	90	162	79	48	83	183	76	51
17	F	71	149	68	42	66	150	59	39
18	F	67	141	64	35	75	195	72	39
19	F	104	182	94	54	88	167	77	43
20	M	96	172	89	55	95	177	86	58
21	M	58	117	53	32	56	115	53	34
22	F	90	151	78	44	77	146	65	41
23	M	121	219	105	62	117	219	99	61
24	M	98	202	93	52	98	210	92	48
25	F	83	177	76	48	83	180	75	48
26	F	75	146	70	46	98	197	89	52
27	F	140	250	111	65	111	243	92	55
28	M	149	212	137	80	146	205	135	78

S	Reading Time	Memory IR	Time DR
1	3.88	15.97	14.98
2	3.08	16.88	14.48
3	1.90	6.25	6.79
4	2.33	6.94	6.12
5	2.41	4.99	6.00
6	2.19	5.19	5.64
7	3.12	6.12	7.67
8	2.90	7.63	6.53
9	3.13	9.97	9.67
10	2.13	6.64	7.14
11	2.35	7.07	7.83
12	3.32	4.66	5.63
13	1.75	7.85	9.19
14	3.06	12.53	12.96
15	2.72	7.00	8.20
16	2.34	9.05	7.97
17	1.76	6.99	7.26
18	2.23	5.89	8.43
19	2.32	7.53	9.02
20	1.53	9.50	10.10
21	2.42	6.05	5.59
22	2.45	5.77	5.17
23	3.50	9.82	9.33
24	2.36	9.32	7.22
25	2.15	7.47	6.68
26	2.34	6.62	7.94
27	3.18	11.28	10.86
28	2.48	15.28	9.88

Appendix H

Ordering of Ss on Basis of HR Change During Story

Group	S	Beginning	Mid-Point	End
HA	1	-12	- 6	0
	7	15	6	6
	8	- 3	3	9
	11	-16	-10	-10
	13	6	6	6
	14	13	7	26
	16	17	17	11
	18	9	9	15
	19	6	9	3
	23	18	6	12
	24	9	6	0
	26	15	9	9
	27	21	6	15
	28	12	9	3
LA	2	3	3	3
	3	6	0	6
	4	- 3	- 6	- 6
	5	0	0	0
	6	0	0	0
	9	3	3	- 3
	10	0	0	0
	12	- 2	4	- 2
	15	0	0	0
	17	8	2	2
	20	- 3	0	- 6
	21	6	0	6
	22	9	3	0
	25	6	0	0

Appendix I

Recollection Rating Scale Ratings

Group	S	Immediate Recall				Delayed Recall			
		P-D	I-A	A-R	P-C	P-D	I-A	A-R	P-C
Control	1	7	15	6	11	7	14	9	11
	2	5	12	2	5	9	10	2	6
	3	16	18	1	18	16	17	1	18
	4	9	2	1	16	9	3	2	15
	5	6	14	3	11	5	15	3	7
	6	7	11	7	6	7	9	11	6
	7	8	14	1	18	8	14	1	18
Pre-Story	8	6	13	3	4	14	14	3	3
	9	6	9	4	2	8	11	6	3
	10	2	17	1	5	4	14	2	3
	11	2	17	2	9	2	17	3	9
	12	10	11	8	6	10	11	8	6
	13	3	17	5	9	3	16	4	9
	14	9	15	13	14	9	15	12	12
Post-Story	15	4	18	9	1	14	18	14	1
	16	12	15	7	16	5	17	3	16
	17	6	14	9	11	9	12	11	10
	18	14	13	7	9	12	13	7	8
	19	9	9	5	5	7	9	9	7
	20	3	18	1	12	3	17	3	9
	21	9	11	14	6	9	12	7	7
Pre-Recall	22	7	13	9	13	10	13	8	11
	23	3	17	1	6	3	16	6	8
	24	4	6	5	3	2	5	3	10
	25	7	15	7	12	7	13	7	13
	26	2	17	3	15	2	17	3	15
	27	3	15	13	5	5	15	9	6
	28	7	13	8	7	7	12	9	7

Appendix J

Heart Rate

Accelerates	HR	Decelerates	
S		S	S
1		2	17
4		3	18
8		5	21
9		6	22
11		7	23
12		13	24
19		14	25
20		15	26
		16	27
			28

Ordering of Ss on RRS Accepting - Rejecting (A-R) Scale

Accepting Ss		Rejecting Ss
2	13	1
3	16	6
4	18	14
5	20	15
7	23	17
8	24	19
9	25	21
10	26	22
11	28	27
12		

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