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REPRESSION: A LABORATORY ANALOGUE USING ULTRASOUND

BY

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Repression: A Laboratory Analogue Using Ultrasound

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ABSTRACT

This study was designed as an experimental analogue of repression. Ultra-high-frequency sound (ultrasound) was used as an aversive stimulus which was paired with learned material without the subjects' (Ss) awareness of this contingency, then differential recall was tested.

All Ss were given standard paired-associate learning instructions, learned a paired-associate list to a criterion of two perfect successive trials, then received twelve overlearning trials. Experimental manipulation occurred during these 12 trials when Ss were given varying levels of ultrasound on half of the ten pairs. The three levels of ultrasound used were: (1) 95-97 dB; 20,000 kHz, (2) 86-88 dB; 20,000 kHz, and (3) 0 dB. To test for differential recall relearning trials to the same criterion were given to all Ss one week later. The major hypothesis was that there would be significant differences in recall between the experimental words (EWs; words paired with ultrasound) and the neutral or control words (CWs; words not paired with ultrasound) and that these differences would vary directly with the intensity of ultrasound.

The results did not support this hypothesis, although the highest level of ultrasound appeared to disrupt learning in the early overlearning trials. The problems with devising an adequate test of repression, the use of a new aversive stimulus, ultrasound, in an attempt to resolve some of these problems, and the need for further research in both areas are discussed.

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Repression: A Laboratory Analogue Using Ultrasound

According to Freud (1959, p. 86), ". . . the essence of repression lies simply in the function of rejecting and keeping something out of consciousness." This process occurs when a particular instinct becomes, for a variety of reasons, unacceptable. It is not that the satisfaction of that instinctive urge is no longer pleasurable, but that it is irreconcilable with other purposes, causing pain in one way and pleasure in another or, more simply, causing conflict. In the case of repression the pain avoidance has acquired more motivational strength than pleasure through gratification (Freud, 1959, Vol. 4). Thus a potential (conscious) conflict is avoided by dismissing the instinctive urge. This process occurs most frequently in childhood; later it may be replaced by condemnation, which is the rejection of the undesirable instinct based on judgment (Freud, 1959).

Freud (1959) conceived of two basic types of repression. First occurs primal repression, in which the ideational presentation of the instinct is denied entry into consciousness and simultaneously becomes fixed in that particular form in which it was originally presented. Second is repression proper which consists of the subsequent expulsion from consciousness of all the ideas associated with the repressed "instinct-presentation". When he ordered these as phases of repression, he sometimes included a third one, the return of the repressed, which is when the originally repressed material becomes consciously available again (1959, Vol. III). As Sears (1943) pointed out, anything can undergo repression if it is associated with the primal repression by ordinary laws of association.

In repression proper the rejected material is forcefully pushed out of consciousness, into the unconscious. There it remains, not stagnant, but exerting a powerful influence on conscious material, popping occasionally into consciousness in distorted forms, showing up as neurotic symptoms, parapraxes, and dream symbols.

Freud viewed repression as the basic defense mechanism and a potentially very dangerous one. If successful, enormously important portions of a person's life remain inaccessible. Development in those areas ceases and the associated problems and conflicts generated are never submitted to any conscious and realistic resolution. But totally successful repression is hypothetical only, since it is also totally unobservable. It is partial, or ineffective, repression that is most amenable to study since it has observable correlates, e.g., anxiety. Numerous experimental studies of repression, or partial repression, have been done, all of which concern the second phase or "after-expulsion" portion of the repression process as originally conceptualized by Freud.

Repression: Recall of pleasant vs. unpleasant material.

Early work with the repression hypothesis stemmed from Freud's use of the word unpleasant to describe the type of mental content usually repressed (Sears, 1943). These studies, most of which were done between 1920 and 1940, measured differential retention of pleasant and unpleasant material; unpleasant sensory stimuli, traumatic words, words with long reaction times, and reports of personal experiences were all used as stimuli (see Sears, 1943; Zeller, 1963a for reviews). Two major trends emerged from these studies. Zeller (1963a) reported that 32 out of 46 such studies favored more effective recall of pleasant over unpleasant experiences, thus stressing type-of-affect as the important dimension. Weiner (1962), on the other hand, suggested that the more substantial evidence supports the notion that it is the intensity of the initial experience, whether pleasant or unpleasant, which affects retention.

Differential recall of pleasant vs. unpleasant material was abandoned as an approach until recently when Holmes (1970) criticized the assumption that the affect of the initial experience remained constant over time and suggested that changes in affective intensity over time might be the critical variable. To test his notion Holmes instructed subjects (Ss) to keep a brief diary of their pleasant and unpleasant experiences for seven days, recording the experiences and rating the associated affect daily. A week after these diaries had been returned Ss were asked to write down all the experiences they could remember, then to check these off on their initial records, and finally to rerate all experiences for affect at the moment. His results indicated that, if only intensity at the initial recording was considered, both hypotheses were supported, i.e. in the second recall test Ss recalled more of both the pleasant and the intense experiences. He also found, however, that the predominant change in affect over time was a decrease in its intensity and that significantly higher proportions of those experiences which decreased in affect were forgotton. More unpleasant than pleasant experiences decreased in affective intensity, but this did not reach significance; the degree to which unpleasant experiences decreased in affective intensity was significantly larger than the degree pleasant ones decreased. It seems Holmes' change - of - affect hypothesis may account for earlier data.

The bearing of all these studies on repression is questionable. The earlier studies were theoretically unsound, since Freud did not state that the powerful mechanism of repression would be employed to reject any merely unpleasant event; they were also methodologically unsound, often either based on the erroneous assumption that pleasant and unpleasant events occur with equal frequency in life or not controlled for equal learning (Sears, 1943; Zeller, 1963a). Thus any obtained differences in recall could be attributed to either differential learning or differential forgetting (Zeller, 1963a). Holmes' (1970) study indicates the importance of considering changes in affective intensity as an influential variable in the retention of affectively charged material, but does not offer any insight into the process whereby this works, and so has little bearing on repression.

Repression: Experimental induction of stress.

Once it had been recognized that simply presenting an unpleasant stimulus was insufficient to induce repression, the criterion for establishing potential repression was that some positive drive must be made to conflict with some ego-maintaining function like self-esteem (Goldin, 1964; Zeller, 1963a). The majority of experiments have accomplished this by exposing Ss to some form of stress, which is then connected with the performance of an experimental task. Stress has been induced via hypnosis (e.g. Bobbit, 1963), through the use of painful shock (McGranahan, 1940; Sears, 1943; Erikson & Kuethe, 1963; Glucksberg & King, 1967; Weiner & Higgins, 1969; Tolman, 1959), and, most frequently, by suggesting some intellectual or personal shortcoming. Intellectual failure has been induced either by having Ss perform interrupted vs. completed problem-solving tasks and assuming that the interrupted ones are experienced as failures (e.g. Rosenzweig, 1943) or by evaluating the Ss' experimental performances as negative via false norms or experimenters' comments (Merrill, 1954; Worchel, 1955; Truax, 1957; Aborn, 1963, Zeller, 1963b; Gossett, 1964; Penn, 1964). The former method, which used selective recall of incompleted tasks as the repression criterion, has yielded ambiguous results due primarily to the inequality of initial learning (Goldin, 1964). The latter method, usually done in a learning framework with absolute deficit in retention or relearning following one failure experience as the repression criterion, has been a more fruitful approach, though not without interpretive problems (Goldin, 1964). It rests on the assumption that all experimental tasks are uniformly affected by one failure experience and experimental evidence indicates that failure is sometimes followed by immediate variability in performance, that these performance deficits may only occur in areas that are motivationally important to the Ss (Goldin,1964), and that both success and failure affect subsequent level of performance, including speed of relearning (Weiner, 1966). It is also questionable whether a single experimental failure is a potent enough experience from which to infer a serious threat to self-esteem, especially with regard to intellectual capacity about which student Ss receive such constant feedback in real life. Some studies (Flavell, 1955; Gossett, 1964; D'Zurilla, 1965; Holmes & Schallow, 1969; Holmes, 1972) have circumvented this by inducing threats to sexual identity or personality adjustment.

Since Zeller's (1963a,b) research, originally published in the early 1950's, most of the studies using this particular paradigm (i.e. learning task and recall test, stress induction and recall test) have included a third stage in which the unconscious persistence of the repressed material is measured by a third recall test after the need for defense has been removed by debriefing the Ss. By equating original learning these studies control for whether repression or selective learning is occurring, but the possibility that the selective recall measure obtained after the failure experience may reflect differential learning under the influence of anxiety rather than differential recall remains (Goldin, 1964). Most of the studies which have attempted to remove the effects of the experimental failure experience have demonstrated a poststress increase in recall (Zeller, 1963b; Gossett, 1964; Aborn, 1953; Penn, 1964; Truax, 1957, etc.) but it is difficult to separate out experimentally whether the effects are due to repression removal, the poststress measures serving as additional learning trials, reorganization after failure experience, latent learning, increased motivation, or other factors (Penn, 1964; Goldin, 1964). Penn (1964) controlled for the possibility of dissipation of failure effects over time by including a group in which the ego-threat was not removed and obtained significantly higher recall for the failure-removal group, but numerous other possibilities remain to be tested. Good critical reviews of this line of repression research have been done by Goldin (1964) and Weiner (1966).

Three more recent studies, however, have called to question this entire line of experimentation as evidence for repression. D' Zurilla (1965) included a postexperimental awareness interview in his design and found that 62% of the experimental or "ego-threatened" Ss thought about things related to the threatening task while only 24% of the control Ss dwelled on task-related things. Since repression theory would imply that ego-threatened Ss would avoid thinking about the threat, D'Zurilla suggested that response competition might better explain the obtained recall decrements.

Holmes & Schallow (1969) tried to determine whether reduced recall after ego-threat was due to repression or response competition. To the usual two groups, ego-threatened and control, they added a third or interference group, which was shown a neutral movie. After treatment, all Ss were tested for previously learned words, debriefed, then retested for retention. The results were consistent with interference theory. Like previous studies, there were no differences among groups prior to experimental manipulation and the control group did significantly better than the ego-threat group after manipulation. Most important, however, there was no difference between the ego-threatened and the interference groups; the control group was significantly better than both these groups. After debriefing, the third recall test again showed no difference between groups.

Holmes (1972) replicated this study with one important change. The interference condition was more similar to the ego-threat condition; ego-enhancing material was substituted for the neutral impersonal movie. The results, consistent with the earlier study, were interpreted as supporting the author's notion that the processes resulting in reduced recall were similar for both groups.

If the interference groups had not been included in these studies, the results could have been interpreted as evidence of repression and consistent with earlier studies (Holmes, 1972). It is not actually proven that the processes which produced reduced recall in the interference and the ego-threat groups are identical, so the repression explanation remains open, but it is extremely doubtful now. What is clear is that the three-stage paradigm developed by Zeller (1963a, b) to study repression must be replaced since alternative explanations can account for any data so obtained.

Repression: The search for alternative methods of study.

Individual differences. Early criticisms of the ego-threat studies led to an attempt to explain the contradictory results obtained by looking at individual differences in the selection of defense mechanisms in a given situation. Belmont and Birch (1951) stated that the experimental assumption of universal repression of punished material was a vulgarization of Freudian theory. Eriksen (1952) found Ss who favored completed tasks in recall took more trials to learn and relearn words with long association times than did Ss who favored recall of incompleted tasks. These studies initiated an entirely different branch of repression research, one which relates different cognitive and personality characteristics to modes of defense (see Goldin, 1964, for review), but which is irrelevant to the attempts to develop an adequate laboratory paradigm to study repression itself.

The Glucksberg-King paradigm. Probably the most convincing demonstration of experimental repression to date was done by Glucksberg and King (1967). They had college students learn an A-B paired-associate word list, then read a list of D words, which were members of implicit B-C, C-D chains. Some of the D words were accompanied by unavoidable painful shock. In the subsequent recall test for the original A-B list, the B words that were implicitly associated with the shocked D words were forgotten significantly more often than those that were associated with the control, unshocked words. To check for the possibility of differential retroactive interference mediated by the obtained superior retention of the experimental D words, they assumed that any process that would produce superior retention of experimental words would have the same effect, and compared the effects on A-B recall of experimental shocked D words and experimental positively-reinforced D words. They obtained differential forgetting only with the shocked D words. This finding was subsequently challenged by Weiner and Higgins (1969), who suggested that undetected inequalities in the degree of original learning were responsible for the obtained pattern of retention, and that the results were a confounding of original learning with shock. Using the data from both studies, Glucksberg and Ornstein (1969) demonstrated that the procedure used by Weiner and Higgins could be reversed to show that the Weiner and Higgins analysis had confounded shock effects with differences in original learning. They also pointed out that in the original study when shock was omitted the words associated with shock were not more difficult to learn and easier to forget, as should be the case if the undetected differences suggested by Weiner and Higgins were of critical importance. They submit that the retention variance is probably due to both differences in degree of original learning and to the influence of a painful experience, shock. This seems to be a promising paradigm, but more work needs to be done before it can offer a convincing demonstration of repression.

<u>The application of learning theory.</u> As repression researchers have grappled with problems of design, conceptualization, and interpretation, some major departures from psychoanalytic theory have occurred. Primal repression is rarely mentioned, indeed, "repression" is often used synonymously with Freud's concept of "repression proper". The concepts associated with primal repression, e.g. instinctual urges, have for all practical purposes been abandoned, and although they might be considered similar to primary drives, this has not been a subject of laboratory studies of repression. The second striking difference is in the treatment of the repressed material. The idea of unconscious persistence of the material has been tested repeatedly, but this is rarely discussed in terms of an unconscious (except in the psychoanalytic journals). Martin (1972) has replaced the idea of an unconscious portion of the mind with that of unconscious influences on behavior, thus avoiding postulating a scientifically untestable phenomenon.

Many researchers, in trying to operationalize repression, have abandoned the ambiguity of the original Freudian terminology almost completely, and used a more learning-oriented framework instead. Dollard and Miller (1950) redefined repression as "the symptom of avoiding certain thoughts", conceptualizing it as a symptom which is learned by the principles of reinforcement and maintained by drive reduction of the anxiety and fear associated with certain thoughts. Pointing out that Freud himself stated that "repression denies . . . the translation of the (rejected) idea into words which are to remain attached to the object" (c.f. Dollard & Miller, 1950, p.198), they suggest that "the repressed or unconscious is the unverbalized" (Dollard & Miller, 1950, p.198). Truax (1957, p.188), in attempting to test Freudian repression, redefined rejection from consciousness as meaning that "anxiety-laden material is not available for verbalization." Tolman (1959) emphasized the conceptualization of repression as a performance phenomenon. And Goldin (1964), after reviewing the literature on repression, suggested replacing the psychoanalytic concept of repression with one based on selective learning. He redefined repression as "the selective avoidance of anxiety-inducing awareness" (p. 375) and suggested using a level of awareness model of repression. Since the major experimental criterion for awareness is the ability to verbalize an idea, behavior, or experimental contingency, these redefinitions are essentially in agreement, and still fairly congruent with Freudian notions.

For the purposes of this study a learning-based definition of repression was adopted. Repression here means any learned behavior which, after its association with an unpleasant experience, is subsequently avoided (inadequately performed) without the individual's awareness (ability to verbalize) of the connection between his avoidance behavior and his painful associations to the learned material.

Repression: A Laboratory analogue using ultrasound.

The research on repression remains inconclusive. There has not yet been an accepted laboratory demonstration of the phenomenon. Methodologically, the major problem has been the aversive experience used to induce repression. This experience must fulfill certain criteria. It must be immediately painful without being traumatic, disorganizing, or lasting. It must be discrete, so it can be applied specifically and only to the material to be repressed. Finally, the S must be unaware of the connection between the unpleasant experience and his difficulty in recalling associations to it. This can be achieved by making either the connection or the aversive experience itself subtle or masked so that the S is either entirely unaware of the painful experience or misattributes its source and purpose. Academic failure, personality threats and shock fail to meet all these criteria.

One apparently viable alternative is the use of ultra high frequency sound (ultrasound), which is sound at frequencies above those audible to man (Acton & Carson, 1967). This technically means above 20,000 cycles per second (cps), but since normal hearing for the average adult is only 10,000 cps (Kryter, 1970), ultrasound may be conservatively designated as sound above 16,000 cps.

Ultrasound has been used and studies in a number of fields, e.g. as an alternative to X radiation in medical diagnostics (Warwick, Pond, Woodward & Connolly, 1970), in dentistry with regard to the effects of high speed drills on patients and operators (Gerstman & Reddy, 1970), and in industrial settings which employ high frequency machines for cleaning, cutting (Kaufman, 1968) and other uses. For this study, however, the critical dimension of ultrasound is its potentially aversive effects.

The most direct evidence on this topic comes from the animal studies which employed ultrasound as an aversive stimulus in modifying behavior in the laboratory. Harrison & Tracy (1955) maintained lever pressing behavior in rats by using a noxious auditory stimulus which consisted mainly of high audio frequencies. Barnes and Kish (1957) used offset of a 98dB wide-range frequency noise to teach mice a platform-depression response. Bolles and Seelbach (1964) found that the offset of loud noise, like the offset of shock, could serve as a reinforcer for certain responses, e.g. rearing and window investigating, but not for other responses, i.e. grooming. They also demonstrated that the noise itself served as a punishing stimulus for some responses, i.e. window investigating, but not for the others, rearing and grooming. Though Campbell and Bloom (1965) concluded that the maximum useable nondamaging level of noise was far less aversive than the shock intensities typically used in psychological experiments, Kent and Grossman (1968) and Grossman (1969) found that high frequency sound (specifically sound swept over a range of 20-30kHz) was as effective a noxious stimulus as shock. They used sound successfully as an unconditioned stimulus and also to motivate the acquisition and performance of escape and avoidance learning. Sprock, Howard and Jacob (1967) found that continuous sound at any frequency from 4-19 kHz was ineffective as a deterrent for wild rats, but that intermittent output with the frequency varied an entire octave and out of phase with an on-off timer was an effective deterrent in the laboratory situation.

With humans the evidence is less direct. The aversive effects of varying amounts of exposure to ultrasound on human hearing include subjective reports of headaches, fatigue, nausea and dizziness (Acton & Carson, 1967). Lengthy exposure may temporarily raise the hearing threshhold, and lengthy continuous exposure may cause partial deafness (Bauer, 1969). Safe exposure levels have been established for industrial in-plant noise. Below are the permissible exposure levels according to the Walsh-Healy regulations (Bauer, 1969):

Sound Level (dBa or dB on the A-scale of sound level meter)	Duration per Day in Hours
90	8.0
92	6.0
95	4.0
97	3.0
100	2.0
102	1.5
105	1.0
110	0.5
115	0.25 or less

Two important facts are now evident. First, a limited exposure to ultrasound seems to have aversive, but not dangerous, subjective effects on human hearing. Second, ultrasound has been employed effectively to change behavior, specifically animal behavior. For these reasons ultrasound was selected as the aversive stimulus for this study.

There are, however, still problems with the use of ultrasound in this manner. First of all, though ultrasound does have aversive effects, it is not clear from the literature what the minimum length of exposure must be in order to obtain these effects. There is also some dispute about whether a single continuous audio frequency can be as effective an aversive stimulus as the use of intermittent output and/or sweeping over a range of frequencies (Belluzi & Grossman, 1969; Sprock, Howard & Jacob, 1967). These latter methods seem to ensure the continued aversiveness of the stimulus by preventing adaptation to it and, if the exposure is long enough, serve to prevent selective damage to hearing (Belluzi & Grossman, 1969). Furthermore, though the painful subjective effects of prolonged exposure to ultra-high-frequency sound seem well-documented, Acton & Carson (1967) and Kryter (1970) have indicated that there is some controversy over whether these effects are due to the ultra-high-frequency sounds or to high intensities of audible noise. Another problem in dealing with prolonged exposure to ultrasound is that, although its application is clearly discrete, its aversive effects may be cumulative as well as discrete.

Finally, even if the stimulus is carefully selected to maximize its aversive properties, there is the question of whether it still necessarily functions as a punishing stimulus for the particular response in question. Bolles and Seelbach (1964) suggest that sound has different effects on different responses. They attribute this to response competition, suggesting that if the response elicited by the sound competes successfully with the criterion or punished response and generalizes, then it will effectively change the behavior in question, If, however, the behavior elicited by the sound is neither strong enought to disrupt the ongoing behavior nor incompatible with it, then the criterion behavior will not be inhibited. This is where they view sound as functioning quite differently from shock; shock onset seems to interrupt any ongoing behavior.

Though some questions remain, there is enough evidence to suggest that ultrasound may function as an aversive stimulus to warrant its use in an area where the need for an easily disguisable aversive stimulus seems paramount. The present study used ultrasound as the aversive stimulus in a laboratory analogue of repression. All the requirements to study repression could thus be met in the following three steps:

1. Ss learn unfamiliar material to an equal criterion.
2. Once learned, trials are continued and some of this material is paired with an aversive stimulus of which the Ss are unaware (ultrasound), while the rest of the material is simply presented for an equal number of overlearning trials.
3. After some time has elapsed, a test for differential recall of material paired with the aversive stimulus vs. neutral material is given to all Ss.

The major hypothesis was that learned material which has been paired with an aversive stimulus without the Ss' awareness of this connection would be recalled significantly less frequently than learned material which remained neutral, i.e. that the material associated with pain would be forgotten or repressed.

METHOD

Design

Three groups of Ss were run. The variable manipulated was the level of sound received during the overlearning trials on a paired associate learning task. One experimental group (I) received 95-97 dB, 20kHz; the second group (II) received 86-88 dB, 20 kHz, and the third or control group (III) received 0 dB or no ultrasound during the overlearning trials. All Ss received ultrasound on only half the pairs, either the five pairs designated as the A-half or on the other five designated as the B-half.

The major hypothesis was that there would be significant differences in recall between the experimental words (EWs; words paired with ultrasound) and the control or neutral words (CWs), and that these differences would vary directly with the intensity of ultrasound. Specifically, it was predicted that the Ss in Group I (95-97 dB) would remember significantly less EWs than Ss in Group II (86-88 dB), who in turn would remember significantly less than Ss in Group III (0 dB), and that there would be no differences between CWs for all three groups.

Two major analyses were planned. These were both two-factor mixed design analyses of variance (ANOVA) with dB level as the between S variable and word type (EW or CW) as the within S variable. One of these was planned for the first or recall trial for the EWs and CWs in the three groups, and the other on the number of relearning trials to criterion for the same. To see if the ultrasound disrupted the overlearning process a supplementary ANOVA on the number of EWs and CWs correct during the overlearning trials was also planned.

Subjects

The Ss were 36 male undergraduate students from the introductory psychology classes at the University of Manitoba. Participation in experiments helped them fill a course requirement. Thirty-two other Ss were discarded; thirteen were eliminated due to equipment failures and five were discarded because they either failed to understand the instructions or became too anxious and quit. The other fourteen failed to reach criterion of two perfect successive trials by the end of the 63 trial limit set by consideration of time and data-sheet capacity. This high failure rate was probably due to extreme list difficulty. All trigrams were selected to be low in both meaningfulness and pronounciability in order to ensure all painful associations would be due to experimental manipulation. Random assignment of Ss to one of the three groups and to either the A- or B- half of pairs was done by drawing up a list from a table of random numbers and following that order as the Ss arrived.

Apparatus

Paired-Associate list. The list consisted of ten letter-trigram pairs. The trigrams were selected in pairs matched on meaningfulness from the Archer (1960) norms and on pronounciability from the Underwood and Schulz (1960) norms; thus there were two matched groups, A and B, consisting of five trigrams each (see Appendix A). The criteria for matching was that no matched pair was more than 1.00 different on meaningfulness nor more than 0.30 different on pronounciability. The stimulus letters were selected so that no letter was used that appeared in the first two letters of any response syllable. Each letter was paired with a trigram in which it neither appeared nor was adjacent in the alphabet to the first letter of that trigram.

Ultrasound. Ss were seated at a student's desk at the far end of the experimental room. Exactly 29 inches from each side of this desk was a speaker (University, Mustang, 12"). Each speaker was placed on a stand in order to raise it to the Ss' ear level, thereby ensuring that the directional properties of ultra high frequency sound were maximally used. By covering them tightly with black cloth, the speaker-stand combinations were disguised as projector stands.

On top of each speaker stand was a Kodak Carousel projector. The projector to the right of the S contained 80 response slides in eight randomized orders of 10 and had a shutter mechanism attached to it. The projector to the left of the S presented the 80 stimulus slides in the identical order. This projector (Projector Programmer PP153, Davis Scientific Instrument) had within it six electric eyes which can be activated by light passing through a small hole punched in any of six positions on the slide frames. For those slides to be accompanied by ultrasound a hole was punched in either position 1 (A-half) or position 6 (B-half). Sound onset occurred when the slide reached the bottom of the projector magazine, and offset was when slide removal began. This meant that ultrasound was on for four seconds at a time. In the adjoining room was the selector switch to activate either position 1 or position 6 of the slides.

Behind the speaker to the right of the S were two long tables on which rested a Sony tape recorder and microphone, which was connected to a speaker in the adjoining room. Also in the experimental room was a small panel with a chime on it. This was wired to a panel in the adjacent room from where the chime could be rung.

The adjoining room was connected to the experimental room by conduits and a one-way mirror. A second mirror was arranged so that the projected syllables were reflected to the experimenter (E) seated in the adjoining room. This latter room contained the rest of the apparatus. The ultrasonic sound was produced by a special wide-range oscillator (Hewlet Packard H20-00CD) and amplified by a 70 watt amplifier (Brute 70, from Popular Electronics, Feb. 1967). The amplifier was modified to filter low frequency noise while yielding nearly flat response from 18-100 kHz. To monitor both ultrasound onset and stability of sound frequency an oscilloscope was wired to the amplifier.

The sound frequency used was 20 kHz. Two different sound levels were used. One experimental group received 95-97 dB; the second received 86-88 dB. Measurements were made by sound level meter held approximately at ear level of a seated S. Two Hunter timers were used to advance the projectors. The projectors advanced together so that each stimulus slide was on for four seconds. After the first two seconds the shutter mechanism opened to present the response slide beside the stimulus one, resulting in a standard paired-associate two second presentation rate.

Procedure

Each S was run individually for two sessions exactly one week apart. Before each S was admitted to the laboratory the random assignment sheet was checked and the appropriate switches for either condition I, II or III, subgroup A or B, were set. After entering the laboratory S was seated in the student's chair. After he was seated the following instructions were read to him by one of the two Es:

> This is a learning experiment in which you will learn to associate letters and nonsense syllables. It is very important that you follow the instructions to the best of your ability. Should you fail to follow any instructions, be sure to tell me since the interpretation of the results may be affected.
>
> The list will consist of 10 pairs of items like the pair on this card (E gives S the example card with the letters B-GUR printed on it). These pairs will be presented on the wall in front of you. When we begin, the letter will always appear on the wall alone. After a short time the nonsense syllable will be presented beside it. Your task is to associate or connect the letter with the nonsense syllable, so that you will be able to spell the nonsense syllable aloud while the letter is on the wall alone, that is, before the syllable actually appears. With this example, if the letter B appears, you would say _______ (E pauses and waits for S to spell GUR, then indicates correctness). Since the order in which the pairs follow each other will not always be the same, you must learn these pairs as pairs and not in the particular order in which the pairs follow each other.
>
> When I start the projectors you will go through the list once silently so that you can study the list and try to make associations between the members of the pairs. After you have gone through the 10 pairs once, they will be presented to you again for the second trial. It is on the second trial that, when the letter appears, you must begin trying to spell out the nonsense syllable that goes with it before it appears on the wall. You will know the second trial is beginning by the ringing of a bell in this room. We will then continue to go through the list, while you attempt to anticipate the second members of the pairs before they appear on the wall. You will continue through the list, trial after tiral, until I stop you. Occasionally there will be a blank period. Just rest during this time.

Always try to anticipate the syllable just after the letter has appeared. If you are able to spell the syllable before it appears on the wall I will count it as correct; on the other hand if you say nothing or spell the syllable <u>after</u> it has appeared on the wall I will count it as incorrect.

Always try to get as many of the pairs correct as you can on each trial. You should try to do the best that you can on each trial even though you may have had them all correct on some of the preceding trials. If you are having trouble anticipating some of the syllables or are giving some incorrectly, try not to let this discourage you or prevent you from doing the best that you can. We have found that most students find this type of learning a little more difficult than they first thought it would be.

Now I am going to turn on the projectors, turn on the tape recorder, turn off the lights, then go into the other room. Shortly after I leave the room, the trials will begin.

E then turned on the appropriate mechanisms and left the experimental room. Seated in the control room with the record sheets in front of her, E then initiated the slide presentation. After the first random order was presented E rang the bell to indicate to the S that he was to begin spelling the response syllables aloud. As the S responded E recorded his answers (which, as a check, were also being taped) on the record sheet and, when S reached the criterion of two perfect successive trials, E turned the ultrasound to the appropriate level. Twelve overlearning trials were then given. At the end of these trials E switched off the projectors and the ultrasound and reentered the experimental room. At this point E read the following instructions to the S, meanwhile handing him a new appointment slip for the appropriate time.

That was good. Now, you remember when you signed up that this experiment is in two parts, exactly one week apart. Here's another appointment slip to remind you to come back here next week at the same time for the second and last session. So I'll see you here next ______ (E says correct day, date and time). Thank you.

The second session began in the same manner as the first. E read the following instructions:

> We are going to do exactly the same thing we did last week. You are to relearn the same list of letter-nonsense syllable pairs. This time, however, there is no practice trial. You are to begin attempting to spell out the syllables you remember on the very first trial. That is, as soon as the first letter appears, you are to spell its associated nonsense syllable aloud before it appears on the wall. You will then continue to go through the list attempting to anticipate the second members of the pairs before they appear on the wall. You will continue through the list, trial by trial, until I stop you.
>
> Remember if you spell the syllable before it appears on the wall, I will count it as correct. If you are silent or spell the syllable after it appears on the wall, I will count it as incorrect.
>
> Now I will turn on the projectors and the tape recorder and, once again, the trials will begin shortly after I leave the room. (E turns on equipment, then pauses at the door and reads last instructions.)
>
> Remember, you are to begin spelling the nonsense syllables aloud on the first trial this time. So begin as soon as the first letter appears on the wall.

Each returning S was then given relearning trials to the same criterion of two perfect successive trials. No ultrasound was used. After the S reached criterion, E switched off all the equipment, reentered the experimental room, handed the S the detailed (Spielberger, 1962) postexperimental awareness interview (see Appendix B) and read the following instructions:

> OK. Now I would like you to do one more thing before you go. I would like you to fill out this post-experimental questionnaire. Please fill it out <u>very carefully</u> since it may be very important, especially if the results aren't clear. Thank you.

E instructed each S to indicate when he was done, then left the experimental room while the S filled out the interview. After the S had finished the awareness interview, E asked him if he had any questions about the experiment. All questions concerning the effects of overlearning on retention and related subjects were answered orally. No feedback about the use of ultrasound was given at this point since all Ss were drawn from a subject pool of introductory psychology students and communication between them could have contaminated the rest of the experiment. Instead, each S was told that a resumé of the experiment and the results would be done as soon as the analyses were completed. This was done late in the summer.

RESULTS

The post experimental questionnaires were examined to determine Ss' awareness of the presence of ultrasound and of the purpose for which it was used. The criteria used to determine this were: (1) The S stated the presence of noise, tingling in his ears, or tingling in his head, and (2) He knew the noise was connected with some of the paired associates, but not with others in the first session, i.e. he knew the experimental contingency.

Using these criteria only two Ss were judged aware, although neither guessed that the noises noticed in the first session were supposed to affect recall for those pairs with which they were presented. Since there were not enough Ss for a separate awareness analysis, it was decided to include them in the regular analysis. Several other Ss mentioned noises or humming, but none of them were aware that these were connected with the experiment in any way. Seven of the eight Ss who alluded to some form of noise were in Condition I, the group which received 95-97 dB. In all, a total of 36 Ss were successfully run, twelve in each of the three conditions.

Main Analyses

Recall Trial. Each S was scored on the number of correct anticipations he gave on the initial (recall) trial of the second session for both the EWs (words paired with ultrasound) and CWs (words not paired with ultrasound). Control group Ss were assigned and scored in the identical way.

Table 1 about here

A two-factor mixed-design ANOVA made up of one within S factor, experimental and control words, and one between S factor, ultrasound level, was then carried out on these data.

Table 2 about here

As shown in Table 2 all the F values for the main effects and for the interaction fell short of significance at the established $p < .05$ level.

Trials to Criterion. Each was scored on the number of trials he took to reach criterion (two perfect successive trials) in the second session. Once again this was done for EWs, and CWs.

TABLE 1

Mean Number of Correct Responses on Recall Trial
(Total Possible = 5)

		Experimental Words	Control Words
I	Ultrasound: 95-97 dB	2.33	2.50
II	Ultrasound: 86-88 dB	3.08	3.00
III	No Ultrasound	3.08	3.67

TABLE 2

Analysis of Variance: All Ss for Recall Trial

Source	DF	MS	F
DB	2	5.68	1.99
Error 1	33	2.86	
WDS	1	0.89	0.87
DB WDS	2	1.36	0.67
Error 2	33	1.02	

Factor 1 (DB) = Ultrasound: 95-97, 86-88, and 0
Factor 2 (WDS) = Experimental Words —— Control Words

Table 3 about here

A two-factor mixed design ANOVA was then on these data. This consisted of one between factor, ultrasound level, and one within factor, word type.

Table 4 about here

As Table 4 shows the F values for the main effects and for the interaction did not reach the acceptable $p < .05$ level of significance.

<u>Analysis of Overlearning Trials.</u> The supplementary analysis of the effects of the use of ultrasound during the overlearning trials, i.e. the immediate effects of ultrasound, was done. The total number correct of EWs and CWs was tallied for each S for each of the twelve overlearning trials. A three-factor mixed design ANOVA was then done on these data. The between factor was ultrasound level, 95-97, 86-88 and 0; the two within factors were word type, EW and CW, and trials, the twelve overlearning trials.

Table 5 about here

As shown in Table 5 a significant Trials effect was obtained ($F = 2.33$; $df = 11$; $p < .01$). A significant three-way interaction between sound level, trials and experimental words ($F = 1.75$; $p < .05$; $df = 22$) was also obtained. While the latter is difficult to interpret, inspection of Figure 1 suggests that this

TABLE 3

Mean Number of Trials to Criterion: Second Session

	Experimental Words	Control Words
I Ultrasound: 95-97 dB	9.42	8.67
II Ultrasound: 86-88 dB	6.08	5.67
III No Ultrasound	6.33	6.50

TABLE 4

Analysis of Variance: All Ss for Number of Trials
to Criterion in Second Session

Source	DF	MS	F
DB	2	68.85	1.33
Error 1	33	51.68	
WDS	1	2.00	0.66
DB WDS	2	1.29	0.43
Error 2	33	3.01	

Factor 1 (DB) = Ultrasound: 95-97, 86-88 and 0
Factor 2 (WDS) = Experimental Words —— Control Words

TABLE 5

Analysis of Variance: All Ss for All Overlearning Trials

Source	DF	MS	F
DB	2	13.06	2.78
Error 1	33	4.70	
TRL	11	0.88	2.33**
DB TRL	22	0.52	1.38
Error 2	363	0.38	
WDS	1	0.02	0.03
DB WDS	2	0.06	0.10
Error 3	33	0.63	
TRL WDS	11	0.34	1.17
DB TRL WDS	22	0.51	1.75*
Error 4	363	0.29	

*$p \leq .05$
**$p \leq .01$

Factor 1 (DB) = Ultrasound: 95-97, 86-88, and 0
Factor 2 (WDS) = Experimental Words — Control Words
Factor 3 (TRL) = Trials: 1-12

was simply the result of the disruptive effects of the onset of the highest level of ultrasound for the experimental words. This might also account for the

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Figure 1 about here

---

overall trials effect; those Ss for whom the onset of ultrasound was initially disruptive for some words seemed to have improved over the overlearning trials.

Additional analyses

In reexamining the questions on the awareness interview, four questions were judged as potentially interesting. Frequency data on two of these warranted additional analyses. These questions were: 2. (d) Were there any factors hindering your concentration on the slides? AND (f) Did you find any noise in the room unpleasant?

Table 6 about here

A chi-square done on the data from 2. (d) was significant at the $p < .025$ level ($x^2 = 8.64$; df = 2, $p < .025$), indicating that group I (95-97 dB) was significantly different from the other two groups. A second chi-square analysis performed on the data from question 2. (f) was also significant ($x^2 = 7.24$; df = 2, $p < .05$). This indicated that the two experimental groups (95-97 dB and 86-88 dB) differed significantly from the controls on the perception of noise.

Both groups who received ultrasound referred to noise significantly more than control Ss did, but it appears that only one of these groups, the high-level

Figure 1

Total number correct: All Ss for all overlearning trials

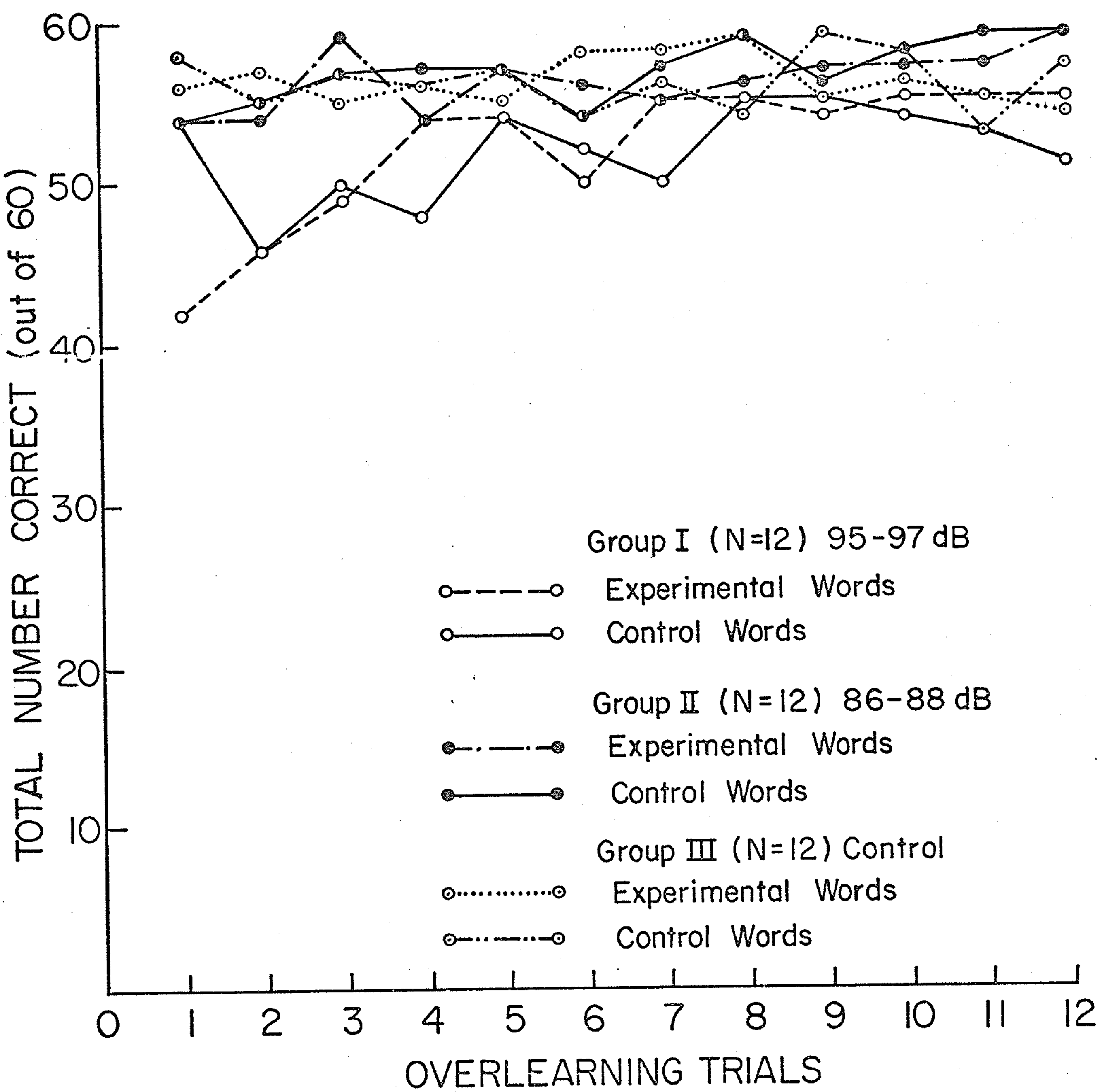

TABLE 6

Frequency of Yes Responses to Two Awareness Interview Questions

	I 95-97dB	II 86-88dB	III Control
Question 2 (d)[1]	7*	1	1
Question 2 (f)[2]	7*	6	1

* Only four of these Ss were the same for both questions.

1 $x^2 = 8.64$; df = 2, $p < .025$

2 $x^2 = 7.24$; df = 2, $p < .05$

ultrasound, experienced this as hindrance to their ability to concentrate on the task. (One aware S in the high ultrasound group specifically mentioned that the high-frequency noises impaired his concentration.) This interpretation is supported by the data from the overlearning trials (see Figure 1) in which the 95 dB experimental group seems to show some initial disruption with the onset of ultrasound, while neither the 86 dB group nor the control group do.

DISCUSSION

Clearly, none of the predicted effects were obtained. Although the means in the predicted direction (see Tables 1 & 3), they fell far short of significance. The hypothesis that there would be significant differences in recall between Experimental words and Control words, differences which would vary with the intensity of ultrasound, was not confirmed.

In general, there are two reasons why this might occur in an experiment. Either the theory being tested was incorrect and is in some way disconfirmed, or the test of the theory was inadequate, i.e. the theory was not actually tested. In this study, the latter seems more likely.

The test of repression, measuring recall decrement after learned material has been associated with a painful experience without the subject's awareness, seems adequate. The problems, many of which were mentioned in the introduction, seem to lie with the functioning of ultrasound as the painful stimulus.

Although the ultrasound seemed to disrupt learning initially, by the end of the overlearning trials (see Figure 1) the effects seem to have dissipated. Some differential effect was obtained, since the Ss seemed to have responded differently to awareness interview questions dealing with noise and distractions. As Eriksen (1962) pointed out, one way to measure the subtle effects of low-level stimulation is by its subsequent biasing of guessing behavior while the individual experiences his answers as vague rather than knowledgable or definite. Ultrasound seems to have affected the Ss' judgments of noise in the experimental situation without necessarily increasing their awareness of any of the specific noises, though they attended more to the projector clicks and hums. The high-level ultrasound group, which seemed to experience this as hindering their concentration, showed evidence of performance disruption at the beginning of the overlearning trials. Thus, however slight the overall effect was, it appeared that learning may have been disrupted by inaudible sound. The important question is why this effect was so minor, so transitory.

One very likely possibility lies in the limitations of the equipment used. Ultrasound is much more aversive and still safe at higher decibel levels (see p. 14). However, the 95-97 dB group was the maximum level this equipment would take before audible buzzing occured. It can be seen from Figure 1 that this level was slightly more disruptive than the 86-88 dB level, though whether this would increase as decibel level increased is speculative.

A second possible explanation is that adaptation may have occurred relatively easily. It was originally thought that using the ultrasound in four second stretches would be sufficient to prevent adaptation to it, but this may not have been the case. Some experimenters have suggested that sweeping the sound across a range of frequencies (Grossman, 1969; Kent & Grossman, 1968; Belluzi & Grossman, 1969; Sprock, Howard & Jacob, 1967) may be helpful in preventing adaptation with animals, though on-off mechanisms were sometimes employed for this reason.

Another factor which may have contributed to the weak overall effect of the ultrasound in this situation is that the paired associate list was an extremely difficult one to master. It took subjects an average of 37 trials to reach the criterion of 2 perfect successive trials; 14 subjects failed to reach this criterion within the established limit of 63 trials. This suggests, first of all, that there was some selection of subjects according to list difficulty. Furthermore, by the time the ultrasound was finally used, mastery may have become so important to the subjects that the effects of another stimulus might have been minimized. As Bolles and Seelbach (1964) suggested, ultrasound seems to have different effects on different responses. In this case it simply may not have been potent enough to compete with a task on which the subjects had been concentrating for so long.

Two other possibilities with regard to the use of ultrasound remain. It simply may not be potent enough to induce such dramatic changes in behavior (Campbell & Bloom, 1965). Or it may not actually be aversive to human ears; it may be high level audible sound which produces aversive subjective effects rather than ultra high frequency sound (Acton & Carson, 1967; Kryter, 1970). In either case, its value for psychological experiments ceases either because it duplicates the functions that shock now serves or because it serves little function at all.

The major shortcoming of this study seems to have been the use of ultrasound before its properties were fully understood. Future research should probably first concentrate on ferreting out how ultrasound actually affects human hearing, on answering some of the questions just raised.

As a result of these uncertainties surrounding the functioning of the ultrasound in this study, the repression paradigm was not actually tested. The intriguing question of whether this type of painful experience could induce an analogue of repression in the laboratory remains unanswered. If the exact conditions under which ultra high frequency sound would be maximally aversive in short doses could be specified, then this paradigm could be retested as it stands. If this is not possible, then the best alternative would probably be to seek another painful stimulus which could be successfully disguised and employed in the laboratory to test repression in this manner.

APPENDIX A

Paired Associate List

A-Half			B-Half		
Trigram	M	P	Trigram	M	P
TUD	47	3.49	CIB	47	3.44
WIB	33	3.90	YAG	32	3.60
PEH	35	5.04	DIH	34	5.04
XOM	10	5.76	QAZ	10	5.99
YOQ	14	6.37	XAT	14	6.35

M- meaningfulness (Archer, 1960)
P - prounciability (Underwood & Schulz, 1960)

APPENDIX B

Post-Experimental Interview

I would like you to answer some questions about the experiment you were just in. In answering these questions it is important that you think back to last week's session and include your thoughts and feelings about both sessions in your replies. Please answer the questions in their numbered order and do not go on to the next question until you have completed the previous one. Answer every question the best you can. Thank you.

1. The experimenter usually conducts a study expecting certain results. This is referred to as the hypothesis.

   (a) What do you think the hypothesis for this experiment is?
   (b) Exactly how did you think you were expected to respond?

2. Every psychological experiment is designed to measure some variable or variables. What do you think this experiment was designed to measure?

3. An important part of any study is the experimental situation. In general, how did you find the setting of this study?

   (a) Was the temperature comfortable? Yes ______ No______
   Explain.
   (b) Were there any distractions from the other room?
   Yes_______ No________. Explain.
   (c) Did the presence of the tape recorder affect your performance in any way? Yes______ No ______. Explain.
   (d) Were there any factors hindering your concentration on the slides? Yes______ No _______
   Explain.
   (e) Did you have enough time on the slides? Yes______ No______
   Explain.
   (f) Did you find any noise in the room unpleasant?
   Yes_______ No_________ Explain.

4. The presentation used in this experiment is standard for paired-associate verbal learning. Pairs are always presented for brief, equal periods of time in order to prevent you from rehearsing one pair more than another. They are also presented in many different orders so that you will learn the pairs and not the order in which to expect them. This often leads to many subjective effects which we are particularly interested in knowing about.

(a) Did you feel frustrated by the short period of time you had to learn each pair?

Yes________ No ________

Explain.

(b) During either session do you remember thinking that some pairs seemed to appear more frequently than others?

Yes______ No _______

If yes, which pairs were they?

_____F-XOM	_____N-WIB
_____G-TUD	_____R-QAZ
_____J-YOQ	_____S-DIH
_____L-XAT	_____V-CIB
_____K-YAG	_____Z-PEH

Is there any reason you can think of for these particular pairs to stand out for you? Yes_______ No_______

Explain.

(c) During the first session were there any pairs that seemed harder to learn than the others? Yes______ No _______

If yes, which pairs were they?

_____F-XOM	_____N-WIB
_____G-TUD	_____R-QAZ
_____J-YOQ	_____S-DIH
_____K-YAG	_____V-CIB
_____L-XAT	_____Z-PEH

Is there any reason you can think of for these pairs to seem more difficult to learn for you?

Yes______ No _______

Explain.

(d) During the second session were there any pairs that seemed harder to remember than others? Yes______ No______

If yes, which pairs were they?

_____F-XOM	_____N-WIB
_____G-TUD	_____S-DIH
_____J-YOQ	_____R-QAZ
_____K-YAG	_____Z-PEH
_____L-XAT	_____V-CIB

Is there any reason you can think of for these pairs to seem harder to remember for you? Yes_______ No_______

Explain.

5. Actually, there was an objective factor for some pairs to be more difficult than others. What do you think this factor was?

Please check either Category I or II of the following, then check one of the reasons a-g listed below the category you chose.

Please specify in detail the reason for your choices under the section marked Explain.

I. ______ Something about the letter-nonsense syllable pairs.

______ a. Some were actually presented less frequently than others.
______ b. Some had less associations to real words than others.
______ c. Some were easier to pronounce than others.
______ d. Some nonsense syllables were vaguely outlined in red.
______ e. Some were presented for longer times than others.
______ f. The responses (nonsense syllables) were occasionally interchanged between some of the pairs.
______ g. Other.

II. ______ Something in the experimental situation.

______ a. The light increased for some pairs and not for others.
______ b. The noise increased for some pairs and not for others.
______ c. The experimenter wanted me to learn some pairs better than others.
______ d. There was a tingling in my chair for some pairs and not for others.
______ e. There was a tingling in my head for some pairs and not for others.
______ f. There was a tingling in my feet for some pairs and not for others.
______ g. Other.

*Explain.

6. How many experiments have you participated in?

I have participated in ______ experiments this school year. (Include this one)
If you can remember, please list either the names of these experiments or the experimenters name below.

Did any of these experiments involve learning nonsense syllables? Yes____ No____

If yes, how many? ________

Had you heard anything about this experiment before you participated in it?
Yes_____ No _____
If yes, what did you hear?

Thank you very much for your cooperation. I will answer some of your questions now. Later, when these data are analyzed and the results are (hopefully) clear, I will send you a letter explaining this study in much more detail. This will probably be at the end of the term if not later.

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