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ULTRASOUND AS A MISATTRIBUTED DISCRIMINATIVE CUE

BY

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ABSTRACT

The study was an attempt to see if ultrasonic stimulation could be used as a discriminative cue without the _Ss_' awareness that they were receiving a sound stimulus.

_Ss_ were given a cover story that the study was investigating ESP, where the task was to discriminate black and white and coloured slides while blindfolded. For half of the _Ss_, ultrasound was paired with the coloured slides. The remaining _Ss_ received no ultrasound. In addition, feedback on the accuracy of choices was given to one experimental and control group.

Results indicated no overall demonstration that ultrasound was discriminated by _Ss_. However, for males the ultrasound--feedback group was significantly different, while for females there was a significant three-way interaction between ultrasound and feedback over trials.

The need for further experimentation is discussed.

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Ultrasound as a Misattributed Discriminative Cue

A pervasive interest in psychology has been the effects that various forms of stimulation have on behaviour. In this light, the present study is the first in a series of studies investigating the effects on humans of a virtually unexplored stimulus, ultrasound.

Defined as sound above those frequencies normally heard by adults, ultrasound generally ranges upward from between 16 to 20 kHz, depending on age of the population (Kryter, 1970). It is already being applied in a wide variety of settings. In industry, it is employed in drilling, cutting, welding plastics, and mixing liquids (Acton and Carson, 1967; Kaufman, 1968). Physicians examine pregnant patients with ultrasound (Warwick et. al., 1970). As a pest control, it is sometimes successful in controlling wild rodents (Sprock et. al., 1967).

When using ultrasonic devices in industry, several observers have noted that the operators of these devices suffer from headaches, nausea, and excessive fatigue, symptoms that have been collectively termed "ultrasonic sickness" (Acton and Carson, 1967; Kryter, 1970). While it seems that the disturbances reported are partially due to vestibular reactions to intense auditory stimulation (Kryter, 1970), the symptoms are still reported in situations where the tones represent a more narrow range of the sound spectrum and the sound level is not as high (Acton and Carson, 1967; Kryter, 1970).

Acton and Carson (1967) investigated the subjective effects of ultrasonic drills and washers operating at frequencies of either 20 kHz or 16 kHz. Operators of these devices reported the usual symptoms and the authors noted a pressure in their head when close to the source of the ultrasound. They tested three workers in a laboratory at various frequencies and intensities and measured their subjective reactions. It was found that the greatest subjective effects of ultrasonic stimulation were produced at frequencies that were audible, but very near the hearing threshold. In the case of two of their subjects, this was 16kHz at 78 dB sound pressure level. The third subject had a threshold of 13 kHz and reported no subjective effects. While not a controlled experiment, this study seems to indicate that ultrasound produces physical feelings in the people subjected to it. Generally, this study concluded that subjective effects will be produced by ultrasound if the person's range of hearing is close to 17 kHz and the sound pressure at that frequency is above 70 dB.

Other studies, however, have reported that higher frequencies can also produce subjective effects. Skillern (1965) found that the greatest discomfort occurred at 25 kHz, and other authors have noted these symptoms with operators of ultrasonic drills and washers that use a frequency of 20 kHz (Kaufman, 1968; Kryter, 1970).

From these articles it can be concluded that ultrasonic stimulation seems to produce some kind of physical feeling in persons exposed to it, provided that the people can hear fairly high frequencies (around 17 kHz) and the tone is loud enough. It is not known what frequency produces the greatest subjective feelings, or if the tone should be below, equal to, or above the subject's threshold to produce the greatest degree of sensation. However, based on the above studies where frequencies of 20 kHz (somewhat above threshold) produced feelings, it is likely that tones slightly above a person's threshold will produce some sort of feeling and that increasing the intensity will increase the probability of an effect. This level may not result in the maximum effect produced by a high frequency tone, but there should be some feeling produced.

Psychologists have generally ignored ultrasound and its applications. However, several studies have used it with rats as an aversive stimulus in trying to find an alternative to electric shock, a stimulus has a number of disadvantages (Belluzzi and Grossman, 1969; Harrison and Tracey, 1955; Kent and Grossman, 1968). Shock is seen by these authors as an unnatural stimulus and therefore responses to it may not justifiably be regarded as normal forms of learning. Another problem noted was that shock is difficult to present at a constant current as received by the animal, and that animals become difficult to handle with shock. In searching for a different sense modality to stimulate, sound has been used frequently, but usually in the form of intense white noise (i.e., Campbell and Bloom, 1965; Bolles and Seelbach, 1964; Barnes and Kish, 1957; Myers, 1967). However, this stimulation often results in incompatible responses, especially freezing, which interfere with the desired responses (Kent and Grossman, 1968). Ultrasound has been tried as a way of circumventing this problem.

Harrison and Tracey (1955) used a high frequency tone of 15 kHz to condition an escape/avoidance response in rats. Once a steady rate of responding was reached, the intensity of sound was varied. It was found that the response rate was positively correlated with the intensity of the tone. While the tone used was not ultrasonic (for humans or rats) , it did suggest further studies with higher frequencies.

Belluzzi and Grossman (1969) compared a tone varying from 20-30 kHz with electric shock in an avoidance situation. They found that, in general, there was no difference in number and latency of responses between groups. This study shows that, if used effectively, high-frequency sound can be an aversive stimulus for rats. The authors stress the importance of stimulating the range of maximum sensitivity and of controlling for adaptation in maximizing this noxious quality.

Despite these promising results, few additional experiments have explored ultrasound as an aversive stimulus and no one appears to have tried using it in an experimental situation with human subjects. This is surprising, since ultrasound has a unique quality that has several possible applications for psychology. Since it is above a person's hearing threshold, there is no sensation of hearing when the tone is presented, yet it produces a feeling which has been described as "a pressure in the head" (Acton and Carson, 1967). This characteristic of ultrasound presents a possibility of producing a physical sensation in a subject without his being able to correctly label its source. If it could be possible to produce this feeling experimentally, a large number of applications can be seen, including the study of influences on behaviour without awareness and learning without awareness.

The purpose of the present study, as a first step into examining the possibilities of ultrasound, was to see if ultrasonic stimulation can indeed produce some kind of discriminable feelings in subjects and to see if subjects can learn to use these feelings without the knowledge that they are receiving sound stimuli. The basic assumption in a study of this type is that Ss can be made to misattribute the feelings produced by the ultrasound to some other source provided in the experimental environment.

As demonstrated by Schachter and Singer (1962), emotional states are a function of the interaction of cognitive factors with physiological arousal. If the individual experiences a state of physiological arousal for which he has no immediate explanation, he will attempt to understand and label this state using whatever cognitions are available to him in that situation (Schachter and Singer, 1962; Schachter and Wheeler, 1962). These authors aroused subjects generally (with epinephrine) then, through cognitive manipulation, produced in them disparate emotional states. Subjects who were not able to label their arousal states accurately tended to use cues from their environment to do so.

The cognitive aspects of emotion have been demonstrated in more specific naturally occurring emotional states such as pain (Nisbett and Schachter, 1966). In this study, Ss who were given a placebo and told to expect symptoms which in fact were the symptoms of electric shock failed to attribute the feelings of arousal to the electric shock. Instead, they misattributed the feelings to the placebo.

The importance of these studies to the present study is that if subjects can experience an experimentally produced emotion for which they have no explanation, they will tend to use cues from their environment to label their feelings, or they will misattribute their feelings to some factor determined by their cognitions. While not strictly analogous to emotions, the feelings produced by ultrasound may be looked at in the same way. In other words, if ultrasound could produce feelings for which there was no adequate explanation, then it should be possible to have Ss misattribute these feelings to some other source as provided by cues in the experimental setting. If this misattribution occurred, it would be possible to measure the extent to which Ss are able to notice the effects of ultrasound without their being aware of auditory stimulation.

Since the degree of sensation produced by ultrasound at the level used in the present study does not appear to be very great, one problem might be that the manipulation would not be strong enough to produce feelings that would need to be labelled. If this were the case, subjects would not misattribute their feelings to other sources. Another problem characteristic of all sound is that it is possible for subjects to "tune out" stimulation received by auditory channels. If subjects were concentrating on cognitive or intellectual tasks, for example, it would be possible for them not to notice any faint sensations such as might be produced by ultrasound.

As the initial study concerned with ultrasonic applications to human performance, it was decided to try to overcome these problems by maximizing the likelihood that any slight sensations which may be produced by ultrasound would be discriminated by the Ss. Therefore, the experiment was designed so that Ss were given the set of expecting physical sensations of the type produced by ultrasound in a context where these feelings would not be perceived as sound, somewhat as Nisbett and Schachter (1966) did with electric shock. This was achieved by disguising the experiment as an ESP study, where the purpose was to sense through physical sensations whether a black-and-white or coloured slide was being presented to the blindfolded subject (Ultrasound was paired with the colour condition. See the Methods section). The set was intensified by describing as possible sensations that the slides might produce the types of feelings that are often mentioned by persons subject to ultrasound, again similar to Nisbett and Schachter (1966). That is, subjects were told to look for a slight pressure in the head or tingling of the skin as possible indicators of different types of slides (See the Methods section).

Through this design, then, it was hoped that subjects would be focusing their attention on the types of feelings produced by ultrasound, thus maximizing the likelihood that any effects would be discriminated without creating the expectancy for auditory stimulation. Since these feelings cannot be correctly labelled, that is, the tones producing the feelings cannot be heard, and since they should be expecting those types of feelings because of the cover story, it would be expected that subjects would misattribute the source of the stimulation to that provided by the cover story (i.e., to different types of slides being shown). In this way, it should be possible to determine whether ultrasound produces feelings in the subjects without their awareness of the source of these feelings.

It was hypothesized that the groups receiving ultrasound with one type of slide and no ultrasound with the other type would use ultrasound as a discriminative cue in deciding what type of slide is being presented, and further, that the ultrasound groups would not be able to verbalize any awareness of auditory sensations which aided them in their selections.

To increase the precision in evaluating subjects' reactions to ultrasonic stimulation, feedback on the accuracy of each response was provided for one ultrasound group and an equivalent no-ultrasound control group. These groups were included to see if aiding subjects in correctly labelling the feelings produced by ultrasound would enhance their performance. The effects of ultrasonic stimulation may be so slight that subjects might be only partially aware of these feelings and therefore not attribute them to one of the slide conditions. If, however, feedback is given for each response, subjects may learn that these feelings are consistently associated with one type of slide and therefore accurately label them. It was hypothesized, then, that the ultrasound-feedback group would perform better on the task than the ultrasound no-feedback groups, which must rely on internal labeling with no confirmation, and better than both no-ultrasound groups. It was also hypothesized that the feedback group would improve over trials as subjects learned the relationship between the ultrasound effects and the slide conditions.

Since this area is relatively unexplored, it was decided to include both males and females in the study to see if any differences exist in discriminating ultrasound effects. There was no reason to predict a differential performance between these groups, but because the crucial variables in the area are not known, this analysis was included to see if a difference does exist.

In summary, the present study was concerned with demonstrating that ultrasound could produce feelings that were discriminable by subjects even though the source of these feelings was not detected. It was hypothesized that:

1. The groups getting ultrasound paired with one type of slide and no ultrasound with the other type would discriminate the different slides better than the groups receiving no ultrasound.
2. The ultrasound group receiving feedback would perform better than the ultrasound no-feedback group and the

no-ultrasound groups.

3. The difference between the sound feedback and the other three groups would increase over trials.

In addition, the performance of males and females was considered separately to see if any sex of the subject was a relevant variable, although it was not predicted to be.

METHOD

Subjects

Seventy introductory psychology students who were fulfilling experimental participation requirements participated in the study. Ten Ss, tested at the start of the study, were eliminated because of an equipment malfunction, and two Ss were eliminated because they identified sound as the contingency in making their choice on the slides as determined by the post-experimental questionnaire. Therefore, 58 Ss, 14 in both ultrasound groups and 15 in both control groups, were included in the final analyses. Ss consisted of 25 males and 33 females, and ranged in age from 17 to 24 ($\bar{X}$ - 18.9 years).

To control for any E effect in giving instructions, all Ss were given identical instructions, as described below, then were randomly assigned to one of the four experimental groups: Ultrasound-Feedback (S-F), Ultrasound-No Feedback (S-NF), No Ultrasound-Feedback (NS-F), and No Ultrasound-No Feedback (NS-NF). Assignment to groups was accomplished by drawing a slip of paper from a box containing the necessary number of Ss for each group. The assignments made were not completely random, however, because after 16 Ss had been tested, a defect in the speakers was discovered that had been producing audible tones for the two ultrasound groups. The defect was corrected by lowering the sound level, but it was necessary to eliminate the 10 Ss who had been in either of the ultrasound groups. To provide for nearly equal N's at the end of the study, these 10 positions were reinserted into the box from which the assignments were made, thereby increasing the probability that the two ultrasound groups would be selected.

Apparatus

Ss were seated at a student's desk at one end of the experimental room. On either side of this desk, and equidistant (4 ft.) from it, was a speaker (University, Mustang, 12") with a projector on top of it. Due to the highly directional nature of high frequency sound, the speakers were on stands which raised the speaker itself to the Ss' ear level. Each speaker-stand combination was covered with black cloth so it resembled a tall column with a projector on top. Thus, the speakers were disguised as stands for the projectors.

The projector to the left of S presented the slides. This projector (Projector Programmer PP153, Davis Scientific Instrument) had within it six electric eyes which are activated by light passing through small holes punched in various positions on the frames of the slides. For those slides that were to be accompanied by ultrasound, a hole had been punched corresponding to an electric eye which activated the ultrasonic apparatus. Tone onset occurred when the slide reached the bottom of the projector magazine and went off when the slide removal was initiated. Slides which were not to have ultrasound had no holes punched. In this way it was insured that ultrasound onset and offset would be uniform.

The second projector was necessary to justify the second speaker (as a projector stand). This projector, then, was used to cue S as to when he should make a choice about the type of slide being shown. No slides were shown on this projector since only the auditory stimulus of the changing mechanism was important as a cue.

Attached to the arm of Ss' desk was a panel with two buttons labelled "Black and White" and "Colour". These buttons were wired to a panel in the adjacent equipment room which contained a bulb for each button that would light up when that button was pressed. Between these lights was a toggle switch which could be in either the "Colour" or "Black and White" position. When activated (in the feedback condition), if the toggle switch was in the same condition as the button pressed (i.e. both "colour") then a chime would sound in the experimental room indicating a correct choice.

The remainder of the apparatus was also in this adjoining room which was connected to the experimental room by conduits and a one-way mirror. The ultrasonic tone was produced by a special wide range oscillator (Hewlett Packard H20- 00CD) and amplified by a 70 watt amplifier (Brute 70, from Popular Electronics, Feb. 1967) which was modified to filter low frequency noise while yielding virtually flat response from 18-100 kHz. An oscilloscope was wired to the amplifier outputs to monitor ultrasound onset and stability of sound frequency. The frequency of sound used was 21 kHz at an amplitude producing a sound level of 85 dB, measured from where S was seated. This level can cause no damage to hearing (Bauer, 1969) and should be above the hearing threshold of almost all possible Ss (Lehmann, 1967). Two Hunter timers were used to advance the projectors in the proper sequence.

There were ten slides of various geometric patterns used in the practice trials, five of these were colour, five were black-and-white, but they were presented in a random order. The thirty experimental slides were merely empty slide cases except for a small triangle of clear material in one corner on which was written the slide's number. The order of slides was randomly arranged between those designated as "colour" and those of "black-and-white". For the experimental groups, ultrasound was paired with those slides that had been randomly designated as "coloured". This assignment was made because of the general cultural association of feelings with colour.

Procedure

After S had been seated at the student's desk, the following instructions were given:

We are studying an unusual phenomenon concerning the senses. There is evidence that some individuals can sense things in the environment through other than the usual sensory channels. Although there have been many sensational articles in the area, very little is actually known about this form of perceiving. Our study, then, is an attempt to see how extensive this ability is.

In a little while, I will blindfold you, then show you a series of slides, some of which will be coloured, some black and white. Your job will be to try to sense which type of slide is being presented.

We have found that people who have this ability tend to develop a vague sort of feeling that is in some way different from normal feelings. These people have found it hard to describe exactly what this feeling was like, but here are several examples of how some of these people have tried to explain this difference. Maybe these examples will help you notice some sort of difference in your own feelings during the slides. Ss were then read the following examples to help increase their expectancy for feelings like those produced by ultrasound.

For instance, one person said, 'I don't know, just every now and then my body felt slightly different, especially my head.' Another said, 'It seemed like there was a slight change in pressure on my skin.' Or finally, 'Somehow the air around me changed.'

The instructions then continued: We don't necessarily mean that you will feel things such as these, but they are the types of feelings that you might experience. We would like you to try to focus your awareness on your physical feelings to see if you can sense any change in them during the presentation of the slides.

The procedure will be to blindfold you, then present a series of slides which are either coloured or black-and-white. Half of the slides will be coloured, half black-and-white, but of course the order will be mixed up. The projector on your left will present the slides. When you hear that projector advance, focus on your feelings and sensations. Continue to do this until the projector on your right advances. Nothing will be shown on this projector, it is just a signal for you to decide which type of slide is being shown, coloured of black-and-white. If you think the slide is coloured, push the button on your right. S's attention is drawn to the buttons in front of him. If you feel it is black-and-white, push the left hand button. You will have five seconds to push the appropriate button before the projector on your right changes, since your response will not be registered. Be sure to push only one button and push it firmly. We are interested in your immediate reactions, so do not attempt to change your response once it has been made. We will only score your first response so you have nothing to gain by making a second response. Naturally, we don't expect you to get all the slides right. We just want to see if it's possible for you to get more right than you would expect from chance.

At this point it was often necessary to explain the procedure more thoroughly. When it was sure that S understood what he was to do, E gave him the instructions for the practice slides:

To make sure you understand the procedure and to help you focus on the types of feelings produced by these slides, we will show you some practice slides without the blindfold. Remember to wait for the second projector to advance before you make your choice. Again, the right hand button means colour, the left black-and-white. Of course, during these slides you will have visual cues and sensations, but the purpose of the practice trials is to allow you to notice other sensations produced by the slides.

I will go into the other room and advance the slides.

E then left the room and initiated the presentation of the practice slides. No ultrasound was presented during the practice slides. At this time the group assignment was made by drawing a slip of paper from a box. When the practice slides were finished, E returned to the room and gave the following statements:

"That's the type of slides that will be shown. Now I'll put the blindfold on."

A blindfold used in sensory isolation studies was used. This type of blindfold fits over the nose and makes it very unlikely that any light at all can be seen by S. When the blindfold was attached and S had confirmed that he could not see, the instructions continued.

Feedback Condition

One more thing, to help you learn to discriminate the different feelings you may get from the two types of slides, you will hear a chime ring whenever you've made a correct choice. This is just a signal to let you know that you may be responding to the right feelings.

All Ss then were given the following reminder about the procedure:

Remember, the right button means colour, the left, black-and-white. Also, don't respond until the projector on the right changes. Any questions? I will be watching through the mirror to see that everything goes okay.

E again left the room and started the slide presentations. He also set the sound and feedback settings to the appropriate conditions for S's group. The panel lights that indicated S's responses were monitored and the choices were recorded on a data sheet. In addition, for the feedback groups, the toggle switch had to be reset on each slide to the proper condition.

Following the thirty slides, S was given a questionnaire and the following explanation:

Okay, that is the end of the experiment. Thank you for your participation. I would appreciate it if you filled out this short questionnaire before you leave. The purpose of this is to help us understand the phenomenon we are studying and also to improve upon our design for future experiments.

The questionnaire (See Appendix I) was aimed at assessing S's awareness of the ultrasound contingency. Questions followed Erikson's (1960) suggestions on evaluating awareness, progressing from general questions on S's opinion of experimental aims and conditions to specific cues and sensations used by S in making his choice. However, because Ss were drawn from a subject pool where interaction with potential Ss was possible, it was decided not to inform Ss about the use of ultrasound, even though valuable information would be lost as to their awareness of the ultrasonic stimulation. Questions 3e, 4, and 5 were considered especially relevant to tapping Ss' awareness of the ultrasound conditions. Ss were considered to be aware of the ultrasound contingency if they were able to verbalize in the questionnaire the differential presence of an auditory stimulus which aided them in their selections.

RESULTS

The questionnaire were examined to determine Ss' awareness of the presence of ultrasound. All Ss (N=6) mentioning any cues or sensations that could possibly be interpreted as auditory were more closely examined. These Ss were included in the analysis if any of the following criteria applied:

1. The contingencies named were entirely incorrect (N=1).
2. S was in the No Ultrasound group (N=1).
3. The sensation mentioned was a non-auditory experience in the ears, such as tingling or pressure (N=2).

Two Ss, one in the S-F group, one in S-NF, were judged to have indicated sufficient awareness of the contingencies to be excluded from the main analyses. However, it should be noted that these Ss were not entirely correct in expressing the contingencies, since one said colour had a long buzz, while black-and white had two short ones, the other mentioned a buzz on colour which lasted into the next slide period.

The remaining Ss consisted of 14 each for groups S-F and S-NF and 15 each for NS-F and NS-NF groups.

Main Analysis

Each S was scored on the number "correct" out of 30, a correct choice was one which corresponded to that slide's arbitrary designation. Table 1 shows the mean number correct for each group. These scores were then blocked into 6

Table 1 about here
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groups of 5 trials each. A three factor mixed design Analysis of Variance (ANOVA) was then carried out on the data, made up of two between S factors, Sound-No Sound (SNS) and a Feedback-No Feedback (FNF), and a within Ss factor of the 6 blocked trials scores.

Table 2 about here

TABLE 1

Mean Number of Responses Correct (Total Possible = 30)

	Feedback	No Feedback
Ultrasound	17.07	15.57
No Ultrasound	14.66	14.87

TABLE 2

Analysis of Variance: All Ss Over All Trials

(Trials Blocked into 6 Blocks of 5 Trials)

Source	DF	MS	F
SNS	1	5.83	2.18
FNF	1	1.02	0.38
SNS FNF	1	1.74	0.65
Error 1	54	2.67	
TRL	5	0.90	0.70
SNS TRL	5	1.74	1.34
FNF TRL	5	2.75	2.12
SNS FNF TRL	5	2.36	1.82
Error 2	270	1.30	

Factor 1 (SNS) = Ultrasound——No Ultrasound
Factor 2 (FNF) = Feedback——No Feedback

As seen in Table 2, none of the F values obtained for either the main effects or interaction effects reached significance at the $p < .05$ level, although the predicted sound main effect approached significance ($F = 2.13$, df 1, 54, $p > .05$). In plotting the trial-by-trial performance for the groups (See Figure 1),

Figure 1 about here

however, it was noted that there seemed to be more difference between the groups in the earlier trials, but that this difference was eliminated in the later trials. It was thought that this trend could be indicating an effect for ultrasound which was erased in later trials, possibly through adaptation. A post-hoc analysis was therefore carried out on the first half of the trials (ANOVA, 2 x 2 x 3). Although this procedure increased the F values in the expected direction (See Table 3), the values obtained were still less than the $p < .05$ level, (F 3.36, df 1, 54, $p > .05$).

Table 3 about here

Male-Female

As mentioned above, because of the unexplored nature of the area, it was decided to examine any differential results that sex of the subjects may have on the effects of ultrasound. Groups were divided by sex, yielding the distribution in the groups as listed in Table 4.

Table 4 about here

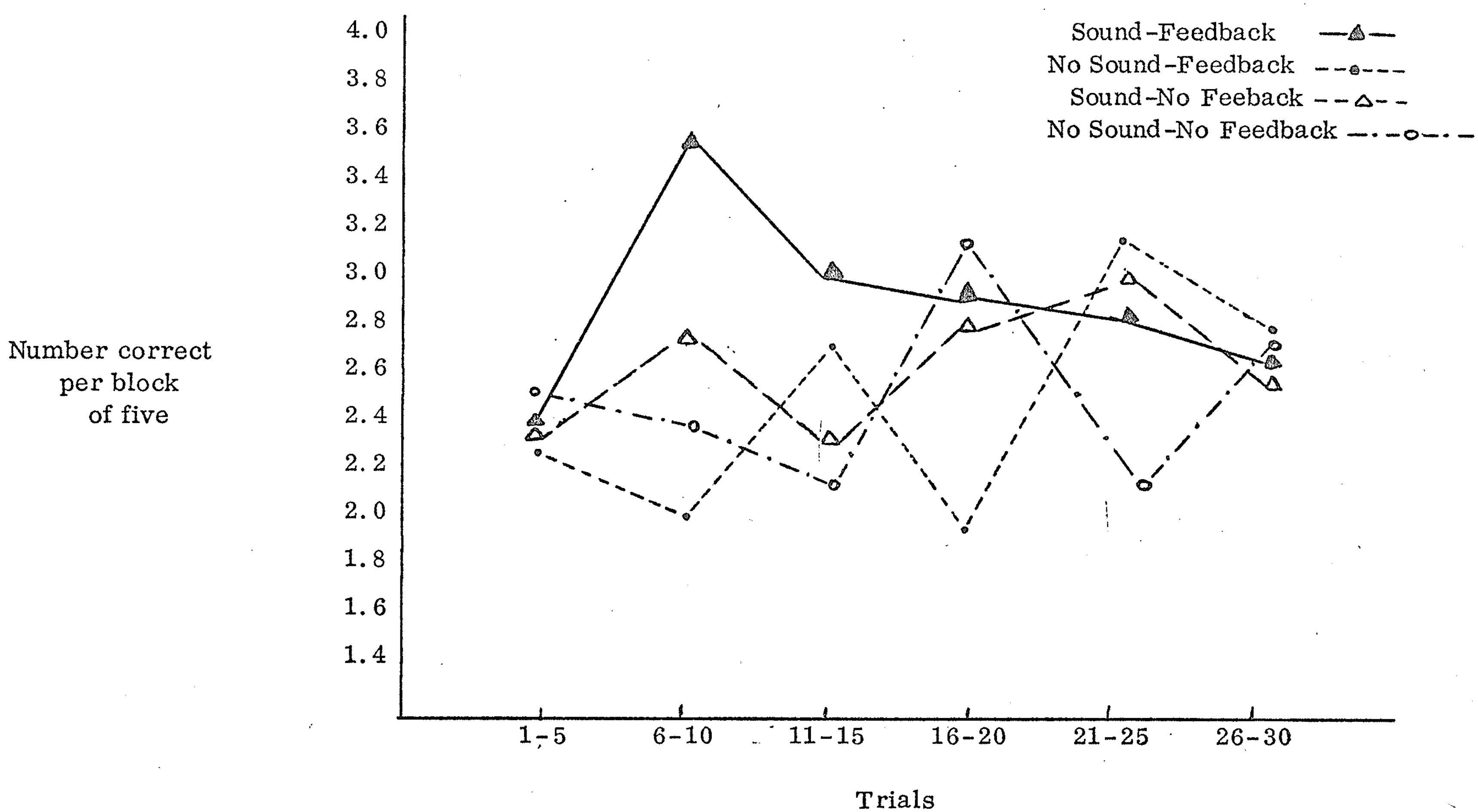

Figure 1: Mean number correct on each block of five trials for all Ss

TABLE 3

Analysis of Variance: All Ss Over First Half of Trials

(Trials Blocked into 3 Blocks of 5 Trials)

Source	DF	MS	F
SNS	1	5.92	3.36
FNF	1	2.72	1.55
SNS FNF	1	2.72	1.54
Error 1	54	1.76	
TRL	2	1.15	0.91
SNS TRL	2	2.98	2.35
FNF TRL	2	2.69	2.12
SNS FNF TRL	2	0.65	0.51
Error 2	108	1.26	

TABLE 4

Male-Female Distribution for Each Group

	S-F	S-NF	NS-R	NS-NF
Males	5	7	7	6
Females	9	7	8	9

A three factor mixed design ANOVA over the 6 blocked trials scores was carried out on both the males and the females.

Table 5 about here

Table 5 indicates a significant interaction ($F = 5.14$; df 1, 21; $p < .05$) in the predicted direction for males between Sound-No Sound and Feedback- No Feedback. As shown in Figure 2, this interaction effect seems to be due to the S-F group, which was consistantly above the other three groups over trials.

Figure 2 about here

For females, however, this interaction was non-signficant (See Table 6). Instead, a significant three way interaction was obtained between sound and feedback over trials ($F = 2.38$; df 5, 145; $p < .05$).

Table 6 about here

While difficult to interpret, this effect seems to be due to the S-F group, which improves rapidly in the first third of the trials, and then declines while the remaining groups improve slightly (See Figure 3).

Figure 3 about here

TABLE 5

Analysis of Variance: Males Over All Trials

(Trials Blocked in 6 Blocks of 5 Trials)

Source	DF	MS	F
SNS	1	12.69	4.00
FNF	1	5.07	1.60
SNS FNF	1	16.29	5.14*
Error 1	21	3.17	
TRL	5	0.73	0.53
SNS TRL	5	1.03	0.75
FNF TRL	5	1.78	1.31
SNS FNF TRL	5	1.71	1.26
Error 2	105	1.36	

* $p \angle .05$

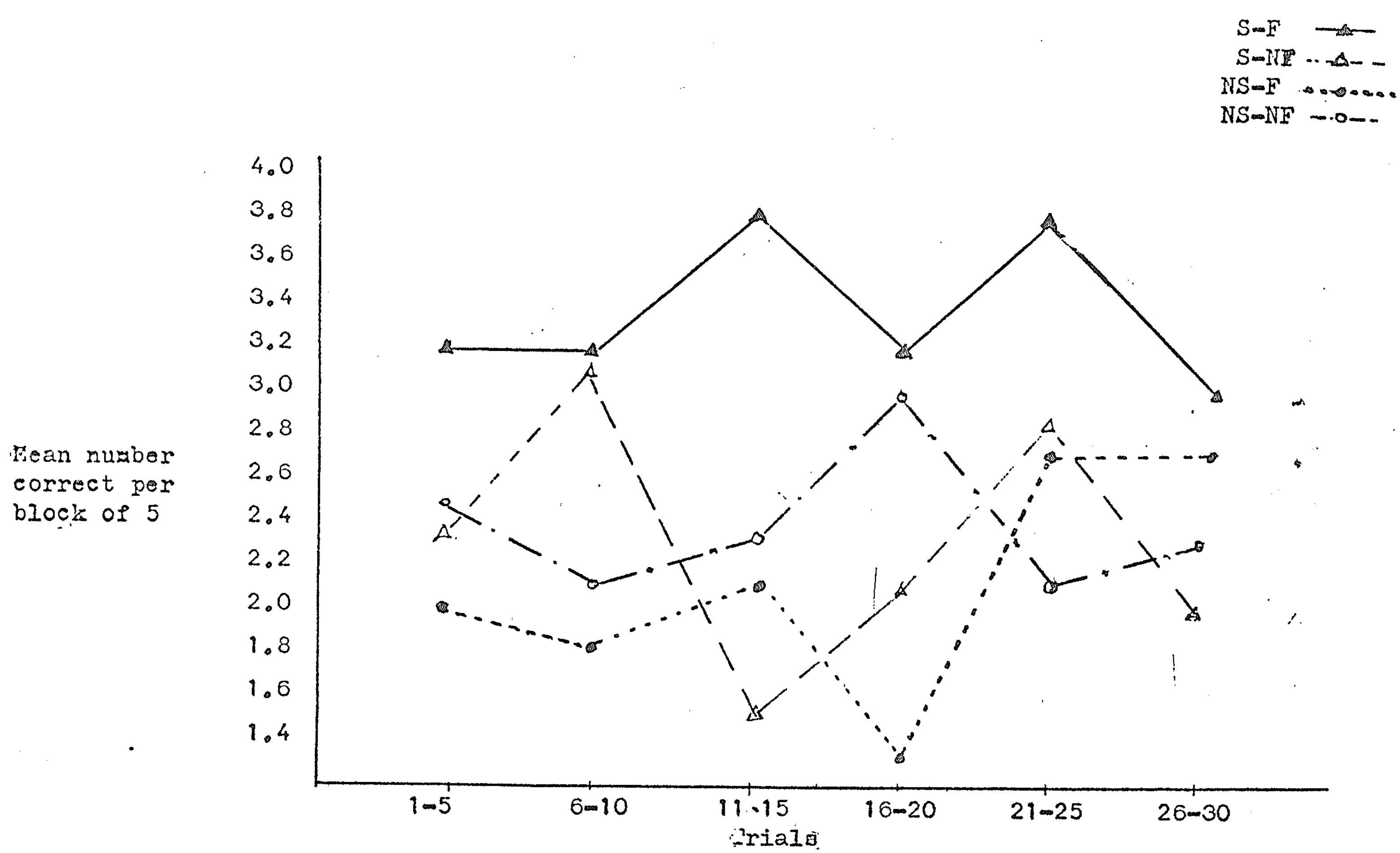

Figure 2: Mean number correct on each block of five trials for <u>male</u> Ss

TABLE 6

Analysis of Variance: Females Over All Trials

(Trials Blocked in 6 Blocks of 5 Trials)

Source	DF	MS	F
SNS	1	0.34	0.19
FNF	1	0.10	0.06
SNS FNF	1	3.21	1.84
Error 1	29	1.74	
TRL	5	1.43	1.14
SNS TRL	5	0.78	0.63
FNF TRL	5	2.18	1.74
SNS FNF TRL	5	2.97	2.38*
Error 2	145	1.25	

* $p < .05$

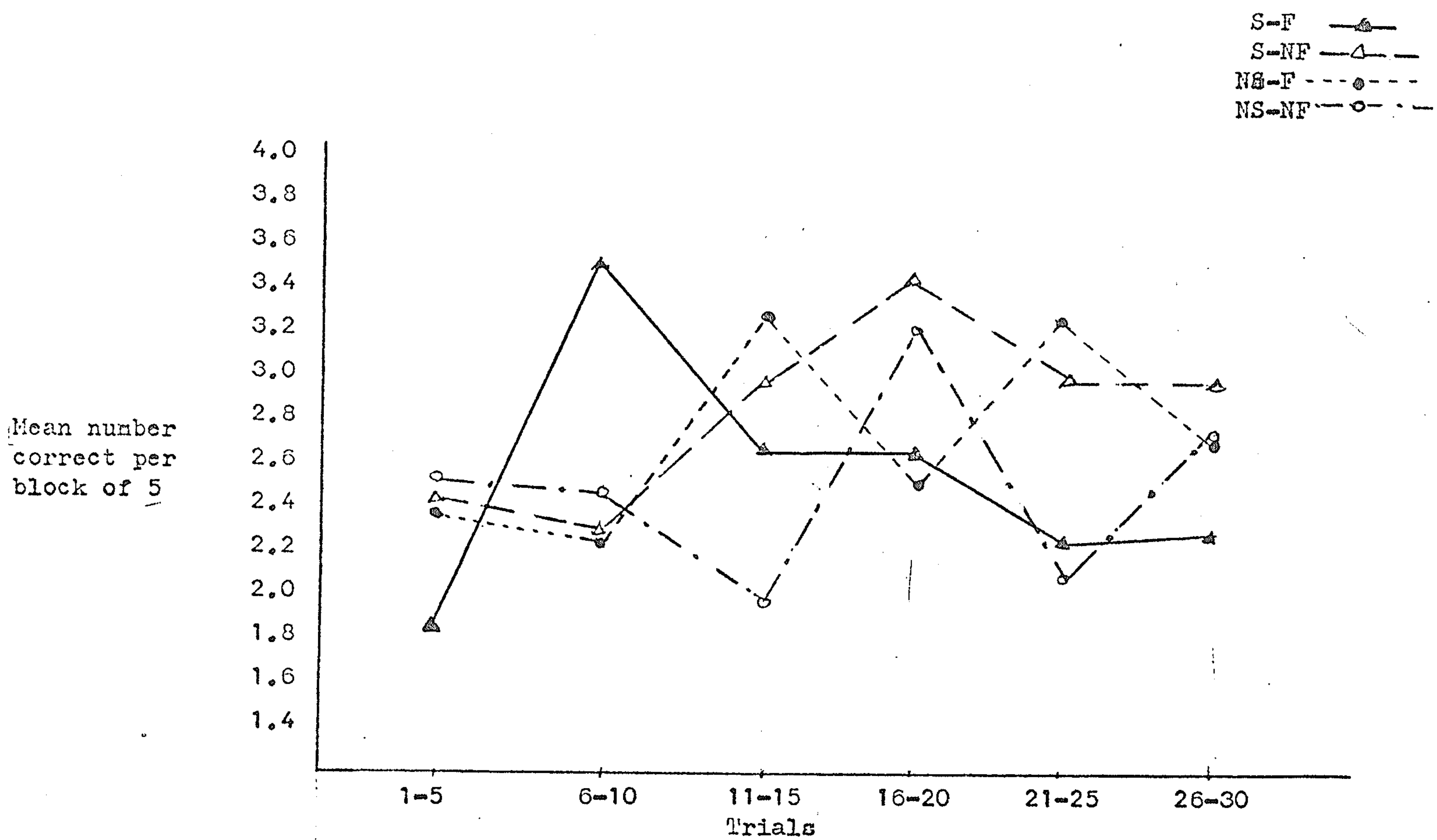

Figure 3: Mean number correct on each block of five trials for <u>female</u> Ss

Deviation Scores

Because of the nature of the experimental design, it was difficult to assess performance of the S-NF group. Since scores were given for what was arbitrarily called "correct"—i.e., pairing colour with ultrasound and black-and-white with no sound, it was possible for the S-NF groups to have been responding to the effects of ultrasound in a consistent manner and still have obtained a low score by pairing ultrasound with black-and-white instead of colour. In this way, the performance of some Ss who paired ultrasonic effects with black-and-white slides would tend to cancel out the scores of those who did the pairing in the "correct" manner. To try to account for this inconsistency, each S's score in all groups was converted into a deviation score from the expected mean correct of 15 (that is, the score that would be expected by chance if no other factors were present in selection). In this way, those who were consistently "incorrect" in their choice were equated with those who were consistently "correct". Table 7 shows the mean deviation score for each group. A 2 x 2 ANOVA was carried out on these deviation scores, yielding

Table 7 about here

the results shown in Table 8. Again, although the results were in the expected

Table 8 about here

direction (Figure 4) they did not achieve significance ($F = 2.23$, df 1, 54, $p > .05$).

Figure 4 about here

TABLE 7

Mean Deviation Scores From the Expected Mean of 15

	Feedback	No Feedback
Ultrasound	$\bar{X}$ = 3.50 SD = 3.11	$\bar{X}$ = 3.86 SD = 2.41
No Ultrasound	$\bar{X}$ = 2.93 SD = 1.91	$\bar{X}$ = 2.53 SD = 2.10

TABLE 8

Analysis of Variance: Deviation Scores for All Ss

Source	DF	MS	F
SNS	1	12.94	2.23
FNF	1	0.01	0.00
SNS FNF	1	2.08	0.36
Error	54	5.81	

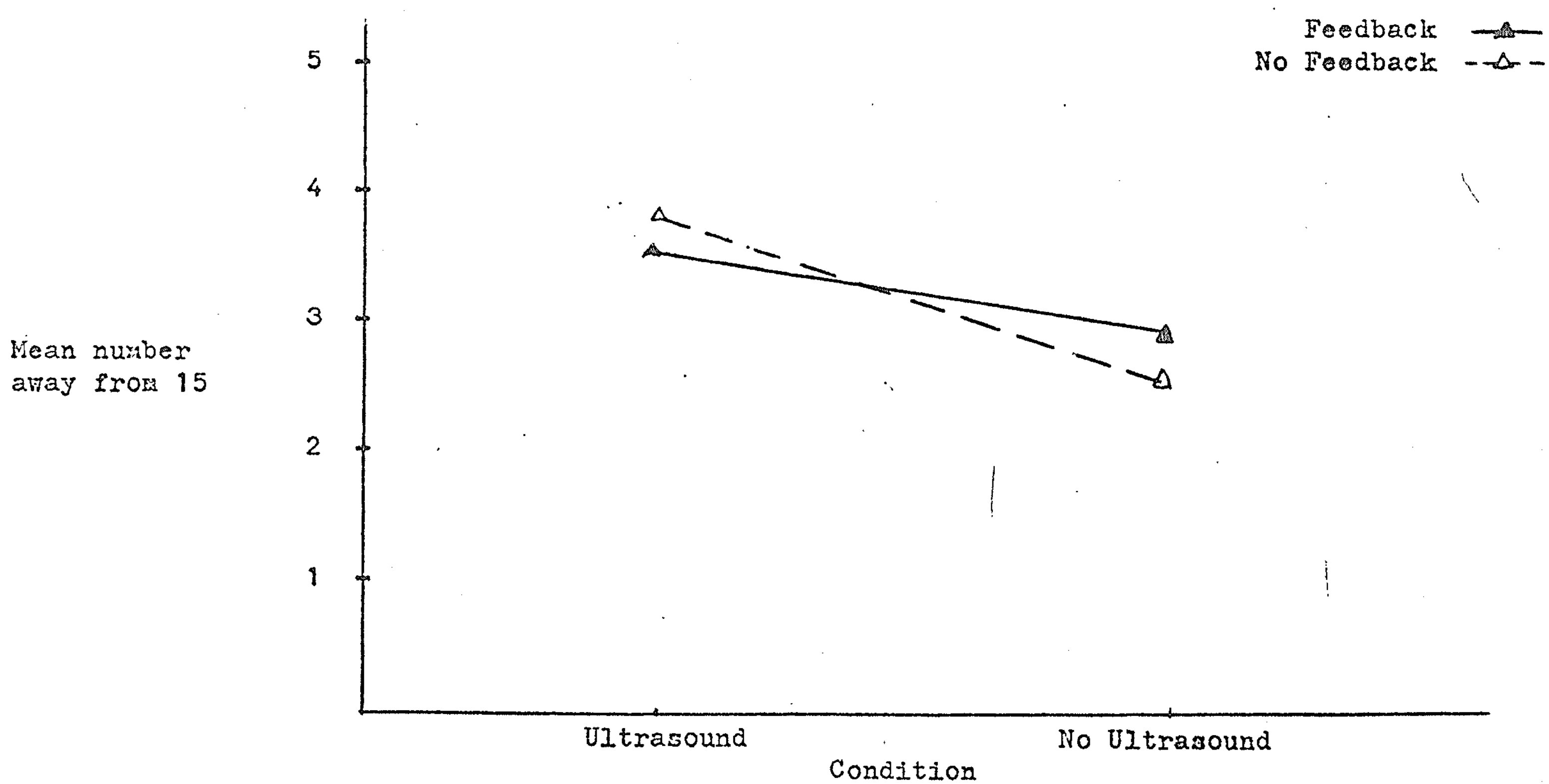

Figure 4: Mean deviation score for each group from an expected mean of 15

DISCUSSION

The data indicated in Tables 1, 2, and 3 show that for all subjects, the ultrasound groups did not differ significantly from the no-ultrasound groups on the experimental task. Thus, the first hypothesis was not supported. In addition, the data on these tables did not support the second hypothesis, that the ultrasound-feedback group would perform better than the other three groups, or the third hypothesis, that the difference between the ultrasound-feedback group and the ultrasound-no feedback group would increase over trials. However, when analysing the data according to sex, the males receiving ultrasound with feedback were significantly different from the other three groups in the expected direction, thus lending support to the second hypothesis, but there was no significant trials effect. For females, however, these results were not obtained. Instead, a significant interaction effect among ultrasound, feedback, and trials was obtained. This difference, however, was difficult to explain and will be discussed below but may have been due to adaptation in later trials.

As noted above, the present study was the initial attempt at applying ultrasound to a psychological experiment with humans. The study was designed primarily to measure whether ultrasound could produce feelings that are discriminable, and to that goal the results can be seen as minimally supporting. While it seems that males are able to discriminate the feelings produced by ultrasound when given feedback on their responses, the female subjects demonstrated no such trend. In fact, females in the ultrasound-feedback group appeared to perform very well on the first third of the trials, then decreased in number correct for the remainder of the trials. The male-female difference was quite unexpected and is difficult to explain. It may be that, as in many other psychological experiments, males simply react differently to the experimental variables than do females. However, there may be other explanations for this difference. One factor which may have biased the results for males was the fact that the three groups other than the Ultrasound-Feedback group performed at a somewhat lower level over trials than did the female subjects. Therefore, the significant difference found for the male S-F group may have been due as much to the lower performance of the remaining males as it was to the higher performance of those subjects in S-F. Replication is needed to separate these alternate explanations.

The female S-F group is puzzling, for it appeared to improve rapidly in the early trials, then gradually decreased in number correct until it became somewhat lower than the other three groups (See Figure 3). This may represent an adaptation effect, where this group learned to discriminate and use the ultrasound effects in the first third of the trials, and then adapted to the sound but continued to try to respond to these effects, resulting in a disruption of performance. This idea, however, is purely conjectural and needs verification through further study.

In general, then, the question of whether or not ultrasound can serve as a discriminative cue has not been affirmed but needs much more investigation.

There is little indication that few significant differences obtained were due to some limitation in the design since the control groups accounted for most rival hypotheses. However, due to the equipment malfunction and subsequent reassignment of subjects noted above, there was the increased possibility of E bias effects. While the original design controlled for E bias effects by random assignment of Ss to groups after the instructions had been given, the reinsertion of the ten positions vacated by the discarded Ss into the selection pool made it more likely that a given S would be assigned to one of the experimental groups. However, there still remained over two-thirds of the control Ss at the time of the reassignment, so the increased likelihood of drawing an experimental S was not very great.

Another possible bias could have occurred when E came in contact with S after the group assignment had been made. This occurred following the practice trials when the blindfold was put in place but was necessary to give the feedback groups the appropriate instructions. It is possible that some E bias could have resulted from this procedure, but the contact was very brief and instructions were kept uniform. However, a more adequate design would have been to assign the feedback-no feedback conditions before this contact was made, but wait until after these instructions to assign the ultrasound condition.

As with all studies attempting to evaluate subjects' awareness of experimental manipulations, the present study is vulnerable to attacks that Ss were actually aware of the ultrasound contingency. While it is true that Ss could have been aware of the ultrasound and not expressed this awareness for any number of reasons, the questionnaire taps what Eriksen (1962) says is the best indicator of awareness, the S's verbal report. Also, it is noted that the study was interested in evaluating whether ultrasound could have an effect while not being perceived as an auditory sensation. In this sense, it was expected that Ss should be aware of the effects of ultrasound, but that they should not be aware that these effects are produced by auditory stimulation. It is, in fact, physically impossible for all but a few people to hear (i.e., recognize as an auditory sensation) a tone of 21 kHz (Lehmann, 1967). Therefore, the problem of Ss' awareness of the ultrasound is not as pressing as other awareness problems since it is physically impossible for an S to be aware of the tone as an auditory stimulus. In other studies on awareness such as subliminal influence studies or learning without awareness there is always the possibility that Ss could become aware of the manipulations or reinforcements that were meant to be concealed because Ss were capable of noticing the stimuli at least some of the time.

Also, it could be argued that Ss might have been aware that some variable was being manipulated to produce the feelings even though they weren't aware that this was an auditory stimulation. While a valid arguement, this point is not crucial to the main purpose of the experiment. The study was designed to see if ultrasound could produce feelings which could serve as a discriminative cue. The notion of misattribution was mentioned as a possible vehicle for examining ultrasound effects without Ss' knowledge that they were being stimulated. If some Ss attributed the feelings produced by ultrasound to some experimental manipulation, it does not discount the fact that ultrasound produced some discriminable feelings.

There are a number of possible factors that could have acted to reduce the effect of ultrasound. One problem, especially with the feedback group, was that some Ss tried to find a pattern to the slide presentations rather than focusing their attention on their physical feelings. Therefore, they may have failed to notice feelings that were actually there. A number of Ss indicated in the questionnaire (question 4) that they were, in fact trying to find a pattern in the slides. This type of problem is related to one in which some Ss did not believe that the phenomenon described in the cover story (i.e., ESP) existed, and therefore made little attempt to notice feelings. It is probably the case that for ultrasound effects to be felt S should be paying attention to his feelings since these effects are expected to be slight.

Also a likely problem is the possibility that the tone used was too far above the hearing threshold of some subjects to have an effect. As noted by Acton and Carson (1967), Ss with low frequency hearing thresholds tended not to notice any subjective effects from ultrasound. While the population used normally has a high enough threshold (over 17kHz), the possibility of at least some of the Ss having incurred permanent partial hearing loss through such activities as listening to rock bands or snow-mobiling is quite high. These Ss would not be expected to notice any effects from ultrasound. While it would have been desirable to screen Ss with low thresholds before the study, the effect of the hearing pretest would produce an undesirable set for receiving auditory stimulation in the actual experiment and was therefore not included.

Another problem possibly reducing the effect of ultrasound is that of sensory adaptation. Several studies mention the rapid adaptation that occurs with ultrasound (Belluzzi and Grossman, 1969; Kent and Grossman, 1968) and it does seem that this effect may have been present with the experimental Ss. Figure 5 plots the performance over trials of all groups receiving ultrasound versus those with no ultrasound. It can be seen that the lines quickly diverge, then gradually

Figure 5 about here

converge until there is very little difference between them. It was on the basis of this rationale that the post hoc analysis was carried out on the first half of the trials, resulting in a larger but still nonsignificant F value. It may be, however, that the effects produced by ultrasound are adapted to even more quickly than as measured by the first half of the trials. As seen in Figure 5, the perofrmance of the ultrasound groups reaches a peak at the second block of five trials, then steadily declines after that. However, this trend could be due to the female Ss, as mentioned above. Further study is needed to determine how rapidly Ss adapt to ultrasound.

In addition, there should be an examination of the most effective frequency and amplitude levels in producing an effect. The levels used in the present study, 21 kHz at 85 dB, were selected because the frequency was above that heard by most adults and the sound level was as high as the apparatus was capable of going without causing breakdown. What is needed is a systematic study using several levels of ultrasound at different intensities.

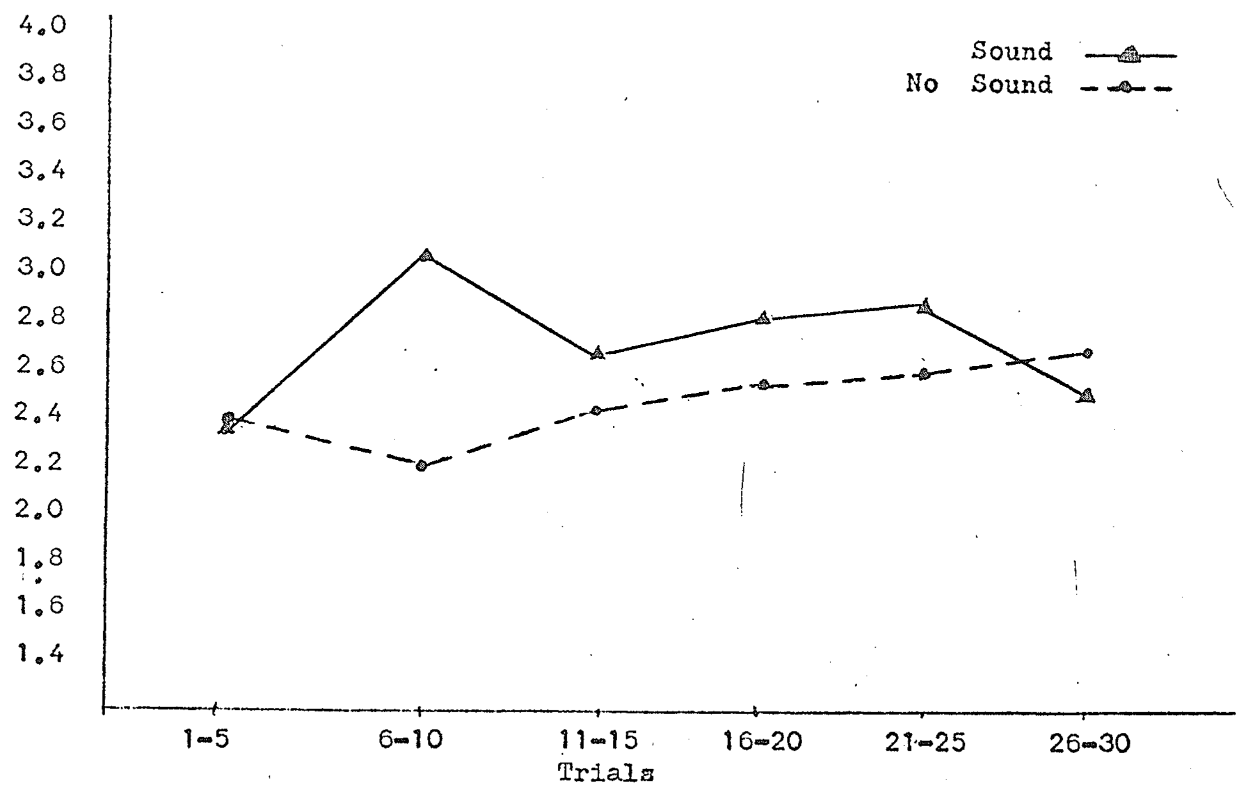

Figure 5: Mean number correct on each block of five trials Ultrasound vs. No Ultrasound

Another improvement in the present design would be to increase Ss' motivation for making correct responses by providing positive reinforcement with each correct choice. In this way it would be to S's advantage to notice any cues which would aid him in his choice.

The present study would be improved by eliminating the no-feedback group or modifying the contingencies somehow so the classification of correct and incorrect responses is not so arbitrary. It is possible that this group would only be able to notice the effects of ultrasound if the feelings produced were fairly strong. In light of the results obtained, it seems that the stimulation did not produce intense enough feelings to be discriminated without some sort of feedback. Another possible conflicting variable with this group concerns the possible aversiveness of ultrasound. There is some suggestion in the literature that ultrasound may be aversive in nature to some Ss. If this were so then the assumption that feelings produced by ultrasound would be paired with colour because of cultural definitions would be wrong. Instead, those Ss finding ultrasound aversive might associate its effects with the black-and-white condition, again because of cultural associations.

Finally, it seemed that some Ss in the present study demonstrated more discrimination of ultrasound effects than others. In order to more fully understand what effects ultrasound may have it would be desirable to find out what characteristics are present in those Ss who react to or discriminate these effects. Tests such as field dependency or Internal-External scales may indicate some Ss who are more likely to notice ultrasound effects. If these trends were found, then in future applications of ultrasound it may be possible to select those Ss who are more likely to discriminate the effects. It may have been differences such as these which produced the male-female differences. For example, males tend to be more field independent than females (Witkin et. al.) and thus may be more attuned to internal cues produced by ultrasound.

The results obtained suggest that ultrasound effects are to some extent discriminable by some subjects. A number of other studies are needed to discover more precisely how discriminable ultrasound effects are and what are the characteristics of these effects. For example, the literature on ultrasound suggests that ultrasonic effects are of an aversive nature. A study is needed to investigate the aversiveness of ultrasound, perhaps at different frequencies and intensities to find the maximum aversive qualities. If ultrasound is not found to be aversive, it might be desirable to see if it could become a conditioned aversive stimulus. Through either of these channels it might then be possible to modify a behaviour or influence learning when the subject is not aware of the source of the aversive stimulus, something which has not been achieved yet.

In a less dramatic sense, ultrasound could possibly be used to fill a need evident in the studies of cognitive aspects of emotion (Schachter and Singer, 1962; Schachter and Wheeler, 1962; Nisbett and Schachter, 1966). These studies caused Ss to misattribute their experimentally produced arousal states to some factor in the environment through manipulation of cognitive cues. However, all of these studies are subject to the criticism that their subjects were not completely without cognitions as to the cause of their arousal. Subjects received shots, pills, or shocks, which no doubt produced certain cognitions which might have been a factor in labelling their emotions. Schachter and Singer note that to solve this problem

> ". . . requires conditions under which the subject does not and cannot have a proper explanation of his bodily state." (p. 388)

This means that the subject must not be aware of any of the experimental procedures which produced the feelings. Ultrasound may be a means of producing a feeling in Ss without their awareness of the source of stimulation.

APPENDIX I

Subjects' Questionnaire

The results of an experiment are more meaningful to us if we know what your ideas, thoughts, and understandings of the experiment just completed. Please answer each of the questions on the following pages frankly and honestly. Please answer them in their numbered order and do not go on to the next question until you have answered the previous question.

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

   a. What did you think the hypothesis for this experiment was?

   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 the study?

   a. Was the temperature comfortable? Yes ____ No _____ (Explain)

   b. Were there any distractions from the other room? Yes_____ No_____ (Explain)

   c. Were there any factors hindering your concentration on the slides?

      Yes _____ No _____ (Explain)

d. Did you have enough time on the slides? Yes _____ No_____ (Explain)

e. Did you find any noise in the room unpleasant? Yes _____ No _____ (Explain)

4. Did you find any particular thing that helped you decide what type of slide was being presented? If so, what was it?

5. In order to assist future subjects in recognizing this sensation, can you describe in detail any physical feelings you noticed during this experiment? Do you know if these feelings were associated with the black-and-white or colour slides?

6. How many experiments have you participated in?

I have participated in _____ experiments this year. (Include this one)

I still have _____ experiments to complete.

7. Had you heard anything about this experiment before you participated in it?

Yes _____ No _____ If "yes", what did you hear?

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