EFFECTS OF REPEATED SESSIONS ON RESPONSE DECREMENT OF A HEAD-SHAKE RESPONSE

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ABSTRACT

EFFECTS OF REPEATED SESSIONS ON RESPONSE DECREMENT OF A HEAD-SHAKE RESPONSE

by Bruce C. Leibrecht

Habituation (defined as response decrement accompanying repeated stimulation) is a widespread phenomenon occurring across the entire phylogenetic range, and as such it is an extremely useful behavior process for the comparative method of analysis. Since habituation is generally regarded as a form of learning, retention is a characteristic of prime concern in the study of habituatory response decrement. The bulk of the existing evidence indicates that habituation of a wide variety of responses is retained for at least 24 hrs., and often for periods up to a week or more. At the same time, many of the findings pertaining to habituation are somewhat contradictory, indicating the need for an adequate preparation for the detailed analysis of the process.

The present study was designed with the foregoing considerations in mind. The major problem investigated was the retention of habituation of the head-shake response (a rapid rotation, or twisting, of the head about the front-to-rear axis) in the laboratory rat. A secondary aim was the further exploration of a promising preparation for the study of habituation.

Eight male and eight female Sprague-Dawley rats, 30 to 60 days of age, served as subjects. Following an initial pretest to screen out "non-responders", Ss were randomly assigned to an Experimental or Control group. Subjects in the Experimental Group received 14 standard

test sessions, 12 and 24-hr. intervals and the last two at 6-hr. intervals. Each test session consisted of 40 30-sec. presentations of the eliciting stimulus (a stream of pressurized air) in the left ear, 30 sec. of no stimulation intervening between presentations. Control *S*s were simply observed for 12 sessions comparable in every respect to those for the Experimental Group except for the absence of the eliciting stimulus. The Control Group served to establish the base rate of the head-shake response.

The results for the Experimental Group indicated that, while the head-shake response exhibited substantial decrement within each session, the decrement was not retained for 24 hrs. Only a slight suggestion of retention was observed with a 6-hr. inter-session interval. The finding of no retention, although not unique, is contrary to a considerable body of previous findings. Whether or not the response decrement was habituatory in nature is therefore questionable.

The head-shake response was found to have a definite base rate, approximately one-sixth as great as the stimulated response level. Females in the Control Group had a significantly higher response rate than males, although there were no significant sex differences for the Experimental Group. Scores for both groups exhibited a high degree of reliability across sessions. While head-shake responses usually occurred within the context of other on-going behaviors, no predominant pattern of responding emerged.

Stanley C. Ratner
Chairman

June 28, 1967
Date

EFFECTS OF REPEATED SESSIONS ON RESPONSE DECREMENT
OF A HEAD-SHAKE RESPONSE

By

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INTRODUCTION

Habituation, defined operationally as response decrement accompanying repeated stimulation, has for some time been recognized as a process of considerable significance. Humphrey (1933), Thorpe (1963), and Ratner and Denny (1964) regard it as the simplest form of learning. One of its most striking features is its generality. Humphrey (1933), in the first comprehensive discussion of habituation, cites examples from a wide range of phylogenetic levels. In the first systematic review of literature dealing with habituation, Harris (1943) includes cases ranging from one-celled animals to the highest vertebrates. Amoeba, hydra, planaria, earthworms, snails, spiders, turtles, rats, and humans represent only a few of the species in which habituation has been observed. The broad occurrence of the phenomenon has led Thorpe (1963) to make the statement that "something like it (habituation) is universal in animals."

The most widely accepted definition of habituation has been summarized by Harris (1943) as "response decrement as a result of repeated stimulation." In spite of the appealing simplicity of this statement, a number of qualifications have been deemed necessary by various investigators. Both Thorpe (1963) and Hinde (1954), for example, maintain that response decrement must be relatively permanent in order to qualify as habituation. However, Thompson and Spencer (1966) take exception, charging that such a qualification is arbitrary since the time course for recovery of a habituated response depends on a number of variables. Nevertheless, the notion of relative permanency goes along with the idea that a change in behavior which is learned should have somewhat lasting effects. Changes which disappear quickly are generally termed either receptor adaptation or effector fatigue. Relatively long-term retention of habituation has been reported by a number of investigators. Hinde (1954), studying the mobbing response of the chaffinch; Rodgers, Melzack, and Segal (1963), working with the "tail flip response" in goldfish; and Keen, Chase, and Graham (1965), dealing with neonatal heart rate acceleration to a tone, found that habituation was retained 24 hours. Numerous other studies report retention for longer periods of time: two to three days for certain components of the orienting reflex in humans (Galbrecht, Dykman, Reese, and Suzuki, 1965); several days for EEG arousal in cats (Sharpless and Jasper, 1956); four days for the earthworm's response to vibration (Gardner, 1966); six days for the startle response in rats (Moyer, 1963); two weeks for nystagmic responses in cats (Brown, 1965; Capps and Collins, 1965); and three weeks for the nystagmic response in humans (Guedry, 1965).

Another qualification is generally considered basic to the phenomenon of habituation. In order for decrement of a response to be considered habituatory, the response involved must be unlearned. Otherwise, the decrement is labeled extinction. However, Thompson and Spencer (1966) again have taken exception with this requirement, choosing to equate extinction with habituation. It is thus apparent that the various investigators concerned with habituation have occasionally found themselves at odds.

Controversy, of course, is not uncommon in the study and theory of behavior of organisms. Nevertheless, apparent contradictions and discrepancies should be cause for concern. One of the sources of discrepancies may be the great variety of preparations (animals and situations employed in the study of a specific process) and their relative differential adequacies. The problem of identifying an adequate preparation is underscored as central to the comparative method of analysis (Ratner and Denny, 1964). Thus, a major step in the comparative method is the establishment of good preparations, these being necessary for detailed analysis of a process. The essential elements in a good preparation include: species, sex and age of the organism, the response to be studied, characteristics of the stimulus, and a base-rate control (Ratner, 1967). Considering the relatively meager amount that is known about habituation, plus the seeming discrepancies among the findings that do exist, there appears to be a definite need for an adequate preparation for its study.

The considerations underlying the present investigation are therefore two-fold. The major problem addressed is the retention of habituation: what are the effects of repeated sessions on the course of habituation? A secondary aim is the further exploration of a promising preparation for the study of habituation. The head-shake response of the rat, elicited by a stream of pressurized air, serves as the basis of the preparation. A 30-sec. stimulus duration plus a fixed inter-stimulus interval (ISI) are utilized. One group of animals is observed as a base-rate control group. In order to test for retention, a series of test sessions are administered at 24-hr. intervals. The rationales underlying these choices are presented below.

The rat was chosen as the species for study primarily because it is an extremely common laboratory animal. However, the rat offers certain other advantages: a great deal is already known about the species, and rats are quite adaptable to laboratory study. Animals between 30 and 60 days of age are used to insure sufficient biological development, yet limit the opportunities for habituation prior to the formal experiment. Both males and females are studied, since possible sex differences are an important consideration in establishing a good preparation. The finding of sex differences, for example, may limit the population from which subjects can be drawn and/or contribute to the understanding of the process of habituation.

The response to receive primary attention can best be described as a rapid rotation, or twisting, of the head about the front-to-rear axis. However, a complete analysis of the sequence, which would involve cinemagraphic techniques, has not yet been attempted. The response, as far as is known, is unlearned, and it appears to be rather stereotyped within and between animals. It is easily identifiable, occurring in all-or-none fashion; rarely is there a question as to whether or not the animal has emitted the response. The first formal work involving the response (Askew, 1966) indicated that it has considerable promise for the study of habituation.

A stream of pressurized air is employed as the eliciting stimulus. It is somewhat less than 100% effective: Askew (1966) found that it did not elicit the response in approximately 25% of the animals tested. However, an air stimulus allows the maximal degree of control and can be manipulated with respect to intensity. Since the occurrence of "non-responders" is likely, a pretest is given to all subjects as an initial screening measure.

The value chosen for the duration of stimulus presentations

(30 sec.) is by usual standards somewhat large. However, it might be pointed out that the concept of "trials", as well as the values chosen to delimit their length, is rather arbitrary. What an experimenter considers a "trial" may not represent any such thing to the organism being tested. Studies of the effect of stimulus duration on habituation have produced inconclusive results. Askew (1966) and Koepke and Pribram (1966) found no significant effects when stimulus duration was varied, although Hinde (1954), Keen (1964), and Keen, Chase, and Graham (1965) found greater habituation with long durations. For the purposes of this study the length of the stimulus presentation is not considered critical. Rather, it is intended that employing a 30-sec. duration will allow the process under study as much freedom to express itself as possible.

As mentioned above, the interval between stimulus presentations will remain constant. Fox (1964) reported that while habituation occurred with a fixed ISI, it did not occur when the ISI was variable. However, Askew (1966) reported that habituation was observed in each of four conditions involving a variable ISI.

As was also indicated earlier, study of the behavior of a base-rate control group constitutes a major part of the experiment. Such study is a critical element in any preparation. Before effects can be attributed to the chosen stimulus (variable), one must establish what occurs when the stimulus (variable) is omitted, but the animal is otherwise in the same test situation. Askew (1966) found the head-shake response to have a zero base rate. However, since the present preparation differs in a number of respects from his, a base-rate control group is necessary.

A number of behaviors in addition to the head-shake response are relevant for study. It should, of course, be obvious that any laboratory experiment takes place against a background of on-going behaviors. Yet it is often the case that all but a narrow, selected behavior are completely ignored. Conceivably, much can be gained by sampling a larger portion of the activities of the animals under study. For example, Gardner (1966) found that as the withdrawal response of the earthworm to vibration habituated, the subject concurrently engaged in other activities, such as feeding. The present test apparatus is therefore constructed so as to eliminate the necessity of restraining the animals. This allows the subjects to remain in a state as close to natural as possible, giving them the opportunity to engage in normal activities. Pilot studies indicate that animals in the proposed test situation engage not only in head-shaking, but in several other kinds of activities as well. It is of interest to ask what effects the test sessions will have on these behaviors. At the same time, it is relevant to ask if any of the observed behaviors correlate with the occurrence of head-shake responses.

The selection of the length of the interval separating test sessions (24 hrs.) was based on previous findings relating to the retention of habituation. The studies cited earlier reported retention lasting from 24 hrs. to three weeks. However, it should be noted that a few studies have failed to find retention for 24 hrs. While Moyer (1963) reported 24-hr. retention of habituation of the startle response in rats, using gross body movement as the response measure, several other investigators found no such retention in dealing with the startle response. Berg and Beebe-Center (1941), using the cardiac response in humans, Lehner (1941), measuring the respiratory response in rats, and Prosser and Hunter (1936), studying the twitch of the gastrocnemius muscle in rats, all found no retention of habituation at 24 hrs. Finally, Askew (1966), working with the head-shake response of the rat, reported no retention of habituation for a 24-hr. period. This last finding is particularly relevant, since the same response is studied in the present investigation.

METHOD

Subjects

Eight male and eight female Sprague-Dawley rats (obtained from Spartan Research, Haslett, Michigan) served as subjects (Ss). The mean age was 49 days at the beginning of the experiment, with a range mean age from 40 to 60 days. The average weight of the females was 150 g. (range from 109 to 206 g.), of the males, 185 g. (range from 96 to 239 g.). All subjects were born and reared at Michigan State University, and all were experimentally naive. They had remained with their respective litters until approximately 30 days of age, at which time they were transferred to small cages housing five or six animals of the same age and sex.

Apparatus

The test stand, on which S rested during all test sessions, consisted of a small platform atop a narrow length of wood (see Fig. 1). The platform, constructed of $\frac{1}{4}$-in. hardware cloth, was $1\frac{1}{2}$ in. by 4 in. by $\frac{1}{2}$ in., open at the top such that short sides extended upward on all edges. Attached to and hanging vertically downward from the edges of the platform were sections of sheet aluminum, forming a "collar" 9 in. long to discourage escape attempts. The platform with its attached collar was fastened to the top of the wooden column with two screws, so that the entire unit could be removed for cleaning. The wooden column was mounted on a round wooden base, 7 in. in diameter, which in turn was attached to a 4-in. "lazy susan" ball bearing. The bearing was fastened by its lower edge to a rectangular hard-wood

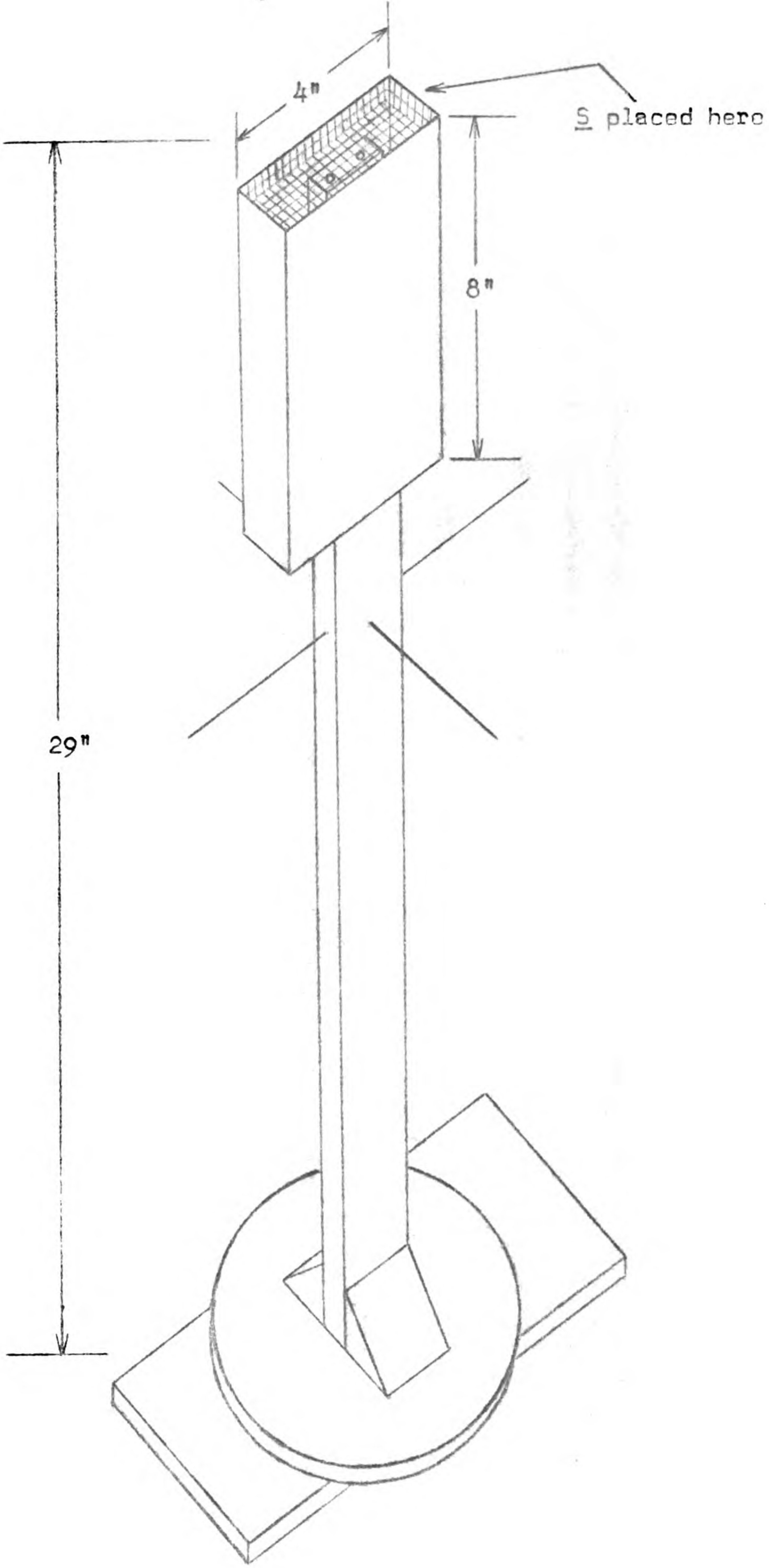

Fig. 1. Test stand. (Scale: $\frac{1}{4}$" = 1")

base, 5 in. by 11 in. Thus the entire test stand could be rotated on its base. To facilitate rotation by hand, brass "spokes", 3½ in. long, extended outward from the wooden column at its approximate midpoint. The total height of the stand was 29 in.

The test stimulus consisted of a stream of pressurized air from a Silent Giant aquarium pump, Model 120. The air was delivered through a hand-held rubber tube, 1/8 in. in diameter. A 1/8-in. long section of smaller rubber tubing was inserted in the end of the hose, effectively making the opening 1/16 in. in diameter. The pressure maintained by the pump was sufficient to displace a column of mercury, measuring 14.8 cm. on both sides of a manometer, a distance of 13.4 cm. It should be noted that the sound produced by the pump was carried through the tube, providing a complex air-tone stimulus.

An Esterline Angus ink recorder was used to record selected behaviors. It was operated by a control panel, consisting of plastic tabs, or "keys", which depressed push-button electrical switches connected to the pens of the recorder. The tabs, attached to a wooden structure, were arranged so that all could be operated simultaneously by the fingers of one hand.

A round metal container with slightly sloping sides, 9 in. in diameter at the bottom and 10 in. deep, was used to convey Ss to and from the test room. A stopwatch was used for timing intervals.

All test sessions were conducted in a small test room, 8 ft. by 8½ ft. (see Fig. 2). A single door with a double glass window led into the room.. Light was provided by two panels of over-head fluorescent tubes; the light intensity at the point at which S rested was 50 ft.-candles. The temperature during all experimental sessions

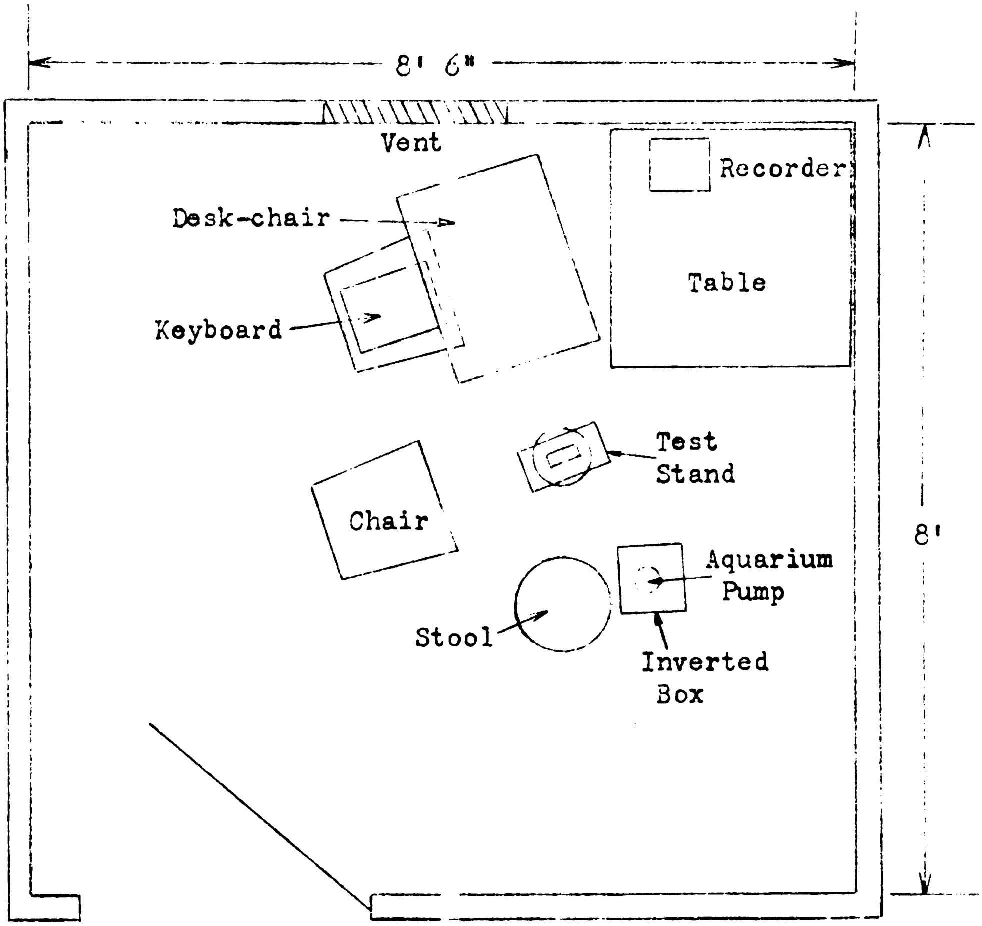

Fig. 2. Test room. (Scale: 1" = 2')

remained relatively constant at 74-76 degrees Fahrenheit. The amount of noise filtering in from the outside was slight. An intake opening for the building's ventilation system was located near the floor of the back wall. This was the source of a constant level of background noise.

All Ss remained in their regular home cages except for experimental sessions. Conditions were maintained according to the established routine of the colony room. Food, consisting of Wayne Lab Blox, and water were available at all times. The lights in the colony room were generally off, except for occasional periods when routine maintenance tasks were being performed or when an animal was being procured for an experiment. The temperature remained at approximately 65 degrees Fahrenheit.

Procedure

Pretest. The initial phase of the experiment involved a pretest for the selection os Ss. The experimenter (E) first selected at random a cage of animals of the appropriate age and sex and marked each animal on the tail with a felt-tip marker. Then E chose an animal at random and held it up by the tail for several seconds to test for damage to the inner ear. Upon finding no evidence of damage, E conveyed the animal to the test room for administration of the pretest. After allowing five minutes uninterrupted on the test stand, E delivered five 30-sec. presentations of the test stimulus directly in the animal's right ear by hand. The stimulus was moved rhythmically back and forth, left-to-right, across the center of the ear at the rate of approximately three complete cycles per sec. and at a distance of 3/8 to 1/2 in. The path of the stimulus lay within the borders of the outer ear and remained as constant as possible. Stimulus presentations were separated by 30-sec. periods, during which E held the end of the tube eight to ten in. away from and out of the visual field of the animal. During the pretest E continuously recorded occurrences of head-shake responses. After the animal had been on the test stand a total of ten minutes, E returned it to the home cage. If the animal had given less than ten head-shake responses during the five stimulated periods, it was rejected. Otherwise, it became an S and was randomly assigned to one of two groups: (1) Control (base rate - no test stimulus), or (2) Experimental (test stimulus in left ear). Four males and four females were assigned to each group.

Tests. Test sessions began on the day following the pretest. E secured S by hand and placed it in the metal container. (Handling during all phases of the experiment was kept to a minimum.) E then conveyed S to the test room, a distance of approximately 50 ft. through an artificially lighted corridor. Upon arrival in the test room, E placed S on the test stand, then turned on the recorder and simultaneously started a stopwatch, which was used to measure all intervals during the session. Then E administered one of the following treatments, depending on S's assigned group:

(1) Group C (Control): S remained undisturbed on the stand for 45 min. while E simply observed.

(2) Group E (Experimental): After allowing S a 5-min. period undisturbed, E delivered 40 30-sec. presentations of the test stimulus in the left ear, in the same manner and under the same conditions as were described above for the pretest. Stimulus presentations were again separated by 30 sec. on no stimulation by E. At the end of the session S remained on the stand for an additional 5 min. without stimulation by E. Whenever S moved its head an appreciable distance during stimulation, E moved his hand accordingly to keep the stimulus directly in S's ear. If an S turned around on the stand, E rotated the round wooden

> base with his foot until S was again in the proper orientation, at which time the "normal" stimulation pattern was resumed. In the event an S succeeded in escaping at any point during the session, E immediately discontinued stimulation and placed S back on the stand. Stimulation was resumed after the next regular 30-sec. period of nonstimulation. If S escaped repeatedly, E terminated the session and returned S to its home cage.

At the end of each normal session E returned S immediately to its home cage.

For the entire duration of all sessions E, operating the keyboard with his left han, recorded occurrences and/or durations of the following behaviors via the mechanical recorder: (1) head-shake responses, (2) head movement, (3) gnashing, (4) washing, and (5) turning around. Head-shake responses, which were clearly identifiable, have been described earlier. Head movement was defined as any observable movement of the animal's head, except the head-shake response; very brief as well as extended movements were recorded. Often head movements were accompanied by gross body movement; such behavior patterns were recorded only as head movements. Gnashing consisted of grinding together of the teeth, accompanied by movement of the lower jaw and occasionally by audible noise. Such behavior frequently occurred along with head movement, in which case both behaviors were recorded simultaneously. Washing, or grooming, consisted of bringing the front limbs up to the mouth and sweeping them back and forth over the head and shoulders. This behavior usually involved head movement as well as what appeared to be gnashing, the entire pattern being recorded singly as washing. Turning around consisted of S's completely turning its body so that it faced the opposite direction on the test stand. When turning around occurred, head movement was recorded simultaneously.

All *S*s received 12 sessions, approximately 24 hrs. apart. In addition, the experimental *S*s received two further sessions, the first at 6 hrs. and the second at 12 hrs. after the end of the twelfth session. It was necessary to run *S*s in three cycles, six *S*s being run during the first cycle and five during each of the latter two. Within each cycle the random running order remained the same for all sessions except 12, 13 and 14. During these last three sessions the experimental *S*s were run in the first positions. Each *S* was weighed following completion of the third session.

RESULTS

The presentation of results will proceed in the following manner. Primary attention will be devoted to the head-shake (H-S) response. The second major section will deal with the remainder of the response measures - head movement, gnashing, washing, and turning around.

Scores involving the H-S response will reflect frequency of occurrence. Data for all response measures within sessions will be organized in successive blocks of 5-min. length, and nearly all within session comparisons will therefore necessarily be made in terms of 5-min. units. Wherever comparisons between groups involve session totals, only data for the first 45 min. of each session for the Ss in Group E will be considered in order to keep the amount of time for both groups equal. Finally, a number of comparisons between Groups E and C will involve response measures taken during "stimulated" periods - those during which the test stimulus was being delivered. Since Ss in Group C never received the test stimulus after the pretest, the term "stimulated" does not truly apply to them. Nevertheless, when applied to Group C it will be used to designate periods corresponding to those which were actually stimulated for Group E.

Preliminary examination of the distributions of H-S scores indicated that they were skewed. Distributions for Group E were generally negatively skewed, while those for Group C were positively skewed. In addition, the shape of the population distributions is unknown, and the number of Ss in each group is quite small (N = 4 for sex comparisons). Therefore, non-parametric techniques were used throughout, particularly the sign test, the Mann-Whitney U-test, and Wilson's (1956) "distribution-free" procedure for analysis of variance hypotheses. Two-tailed levels of significance were used unless otherwise indicated.

During the course of the experiment an occasional session had to be terminated early due to repeated escapes from the test stand. This occurred for both groups, although more often for Group E. In analyzing the data, Ss which had escaped early were assigned scores of zero for the remainder of the session. When the analysis dealt strictly with either of the last two 5-min. blocks of the session, Ss which had escaped were dropped from the particular analysis. It should also be pointed out that the scores for one male S in Group E on sessions 8 through 11 have been dropped completely from all analyses. This S apparently developed an infection during this period (as evidenced by mattered eyes) and his response rate nearly doubled.

Pretest

A total of 21 animals were pretested in order to obtain the final 16 Ss. Five were rejected because they gave less than 10 H-S responses during the stimulated periods of the pretest. Of the 5 rejected, 4 were males; 3 were 40 days of age, 2 were 48 days - none of the 5 animals 60 days of age which were pretested was rejected. The range of stimulated responses for the 5 rejects was 4-9, with a median of 8.5. The range of non-stimulated responses for this same group was 0-21, with a median of 3.

For the 16 animals which became _S_s, the range of stimulated H-S responses was 12-43 (mdn = 19.5). For non-stimulated responses, the range was 0-25 (mdn = 4). _S_s in Groups E and C were fairly evenly divided in terms of total number of responses on the pretest: Group C, median = 28; Group E, median = 27.5.

Head-shake responses

Response level. Scores for the total number of H-S responses per session are presented in Appendix A. It can be seen that all animals from both Groups E and C made H-S responses on all sessions. The range for Group C was 2-177, while for Group E it was 50-278. In order to determine if there were differences between groups and sexes at the beginning of the series of sessions, a 2 by 2 "analysis of variance" (Wilson, 1956) was performed on the total number of H-S responses for session 1. The results indicated a significant difference between groups ($X^2 = 9$, df = 1, $p < .005$) but not between sexes ($X^2 = 0$).

Another 2 by 2 analysis of variance was performed on the total number of responses summed across sessions 1 through 12 to see if the same relationships were reflected in the total number of responses across sessions as in session 1. Again, there was a significant difference between groups ($X^2 = 4$, $p < .05$) but not between sexes ($X^2 = 0$).

A series of Mann-Whitney U-tests on total responses (sessions 1 through 12 combined) was then used to compare response levels during stimulated and non-stimulated periods. No significant sex differences for either group were found. For Group E, the response level during stimulated periods was significantly higher than during non-stimulated periods ($p = .008$, sign test). For Group C there was no significant difference between "stimulated" and "non-stimulated" response levels (p = .36, sign test). Between-group comparisons revealed that the response level during stimulated periods was significantly higher for Group E than for Group C (*U* = 0, p < .001), but there was no significant difference for non-stimulated periods (*U* = 22, p = .27).

Within-session habituation. Medians for the number of H-S responses per 5-min. block (stimulated and non-stimulated periods separate) for 4 representative sessions (1, 7, 12 and 14) appear in Fig. 3. In order to determine if within-session decrement occurred, stimulated responses during the first and last stimulated 5-min. blocks were compared for sessions 1, 7, 12 and 14. For each of these sessions experimental *S*s gave significantly fewer responses during the last block than the first, as indicated by sign tests (session 1, p = .004; session 7, p = .03; session 12, p = .03; session 14, p = .008). Control *S*s during comparable periods showed no systematic changes on sessions 1, 7 or 12. Likewise, no significant changes in the number of non-stimulated responses (first vs. last stimulated block) were observed for either Group E or C on sessions 1, 7, 12 or 14.

As an estimate of the extent of the decrease in stimulated responses for Group E on session 1, the number of stimulated responses during the last stimulated 5-min. block of session 1 was divided by the number of stimulated responses in the first block. A percentage score was thus obtained for each *S* comparing the stimulated response level at the end of the session with that at the first. The range of these scores was 38-82%, the median was 49%. To check the possibility of sex differences in extent of decrease, a U-test was performed on these percentages. No significant difference was found (*U* = 5, p = .24).

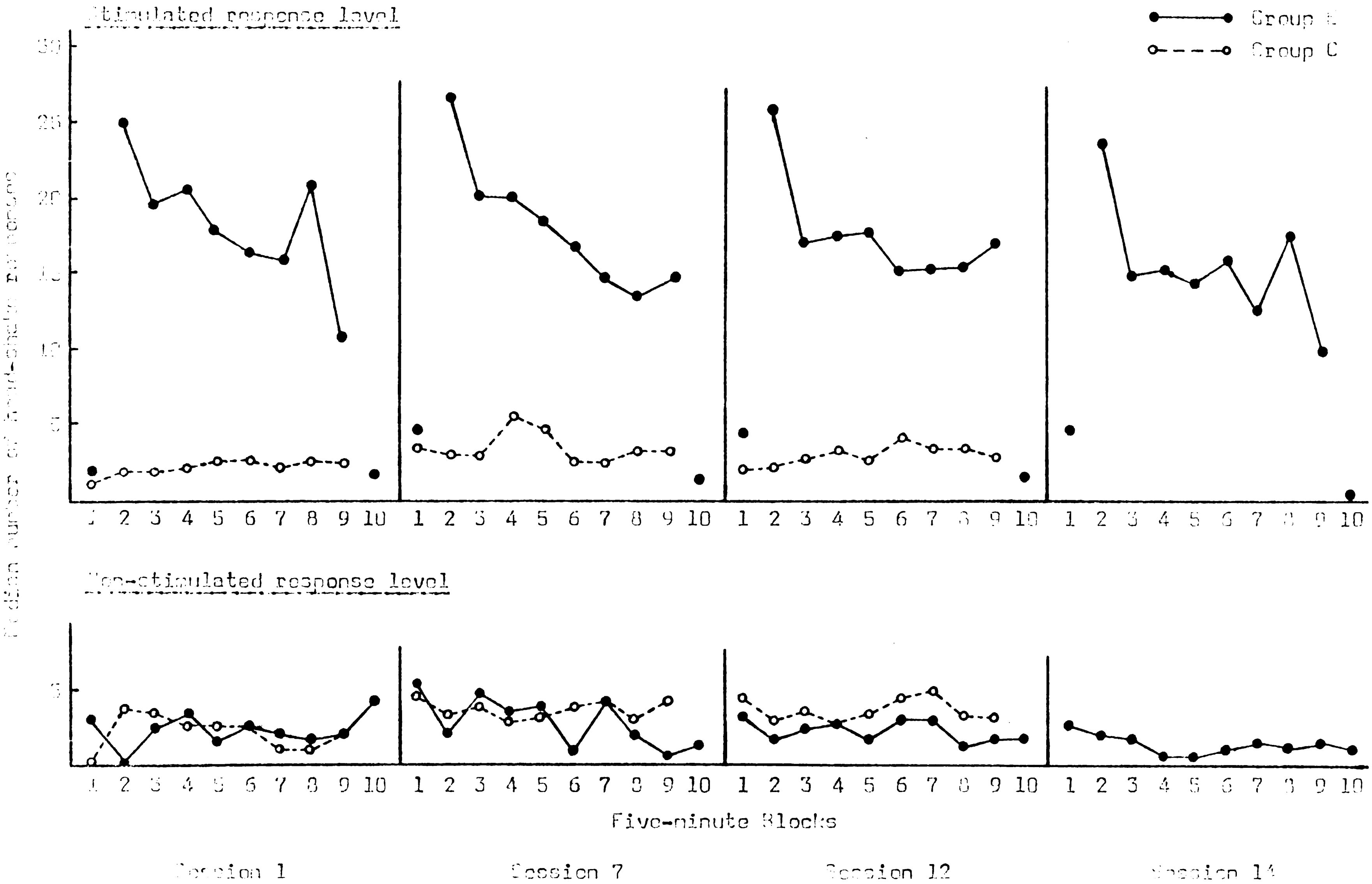

Fig. 3. Median number of stimulated and non-stimulated head-shake responses by 5-min. blocks for sessions 1, 7, 12 and 14.

In order to determine if base-rate response levels changed within a session, the number of H-S responses in the first 5 min. was compared with the number during the last 5 min. for both sessions 1 and 12. No significant changes were found for Group E or C using sign tests.

Changes across sessions. Fig. 4 presents the median number of stimulated H-S responses per session for Groups E and C by sex. Non-stimulated responses are also represented similarly in the same figure. A Wilson (1956) analysis of variance on the data for Group E showed no significant sex differences nor session effects for either stimulated or non-stimulated responses. Two apparent depressions in the curve for experimental males, one at session 6 and one centering around session 10, can be seen in Fig. 4. The reduced numbers of responses at these points were caused largely by early escapes. On session 6, one male repeatedly escaped after only 15 min., necessitating termination of the session. Omitting this S's score, the median becomes 171, as opposed to 123. On each of sessions 9, 10 and 11 the same male escaped after approximately 35 min.; since the scores for one male were already discarded for these sessions due to an apparent infection, the medians may not be representative. The curves for all of the sessions for both males and females in Group E show no systematic decrease in response level as a function of sessions. What shifts there are appear to be closely aligned with premature terminations of sessions for a few Ss. In order to test for changes in the extreme case, the number of stimulated responses (males and females combined) for sessions 1 and 14 were compared. No significant changes were found (p = .14, sign test).

A Wilson analysis of variance on the session totals (stimulated

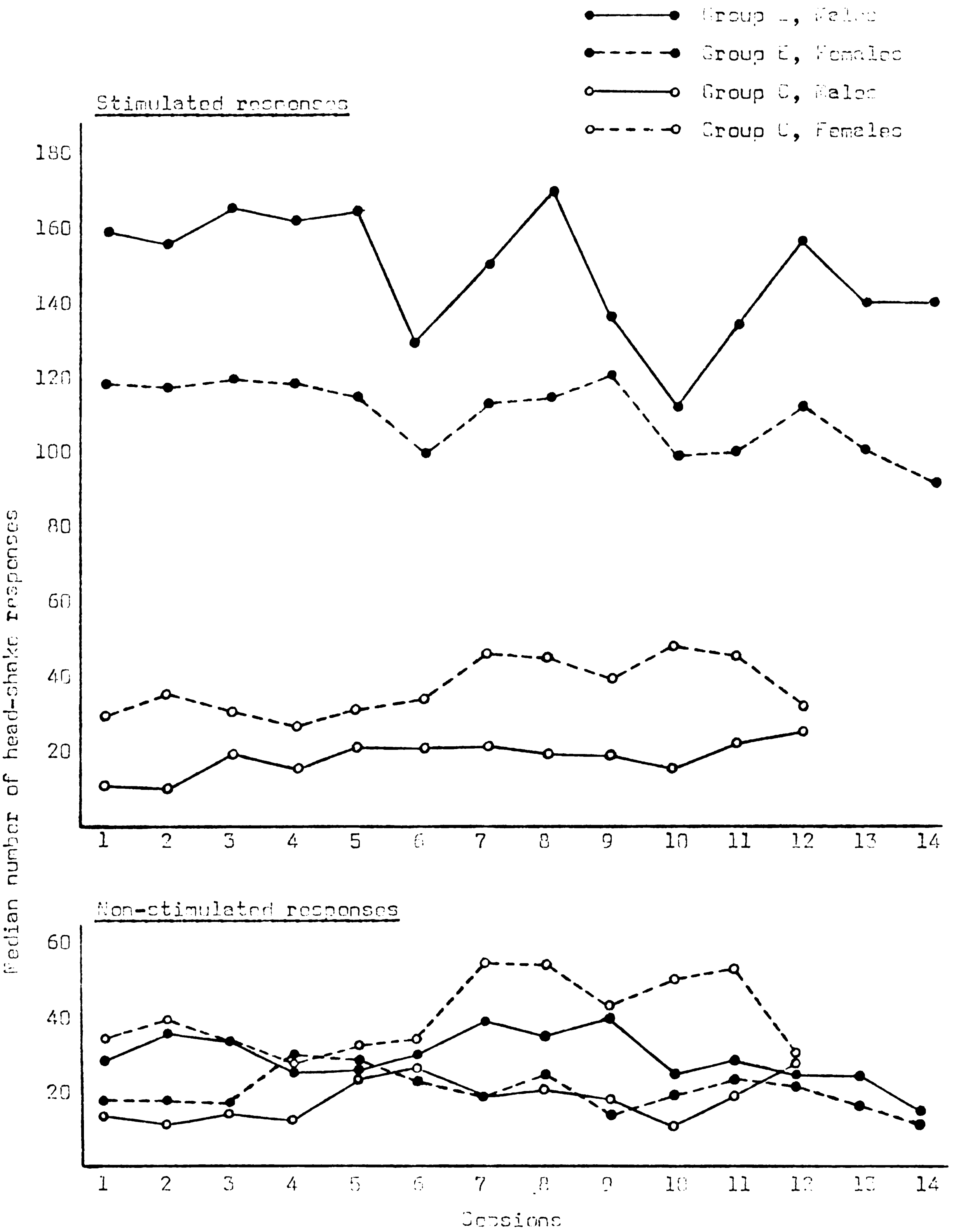

Fig. 4. Median number of stimulated and non-stimulated head-shake responses per session.

and non-stimulated periods combined) for Group C revealed significant sex differences ($X^2 = 8.17$, df = 1, $p < .01$), females exhibiting the higher response level.

Another Wilson analysis of variance was used to compare stimulated responses per session for Group E with the number of responses during comparable periods for Group C. Sexes were combined for each group. Only 9 scores for Group E fell below the median for the combined distributions. This difference between groups is highly significant ($X^2 = 126.6$, df = 1, $p < .001$).

In order to compare Groups E and C on base-level responding, non-stimulated responses per session (sexes combined within groups) were subjected to a Wilson analysis of variance. No significant difference between the groups nor effects of sessions were found (between groups, $X^2 = .08$, $p > .75$; sessions, $X^2 = 3.5$, $p > .97$).

In Fig. 5 the number of stimulated responses during the first and last stimulated 5-min. blocks for each session (Group E and C) are represented graphically. The difference between the starting and ending points for each session represents the amount of drop in stimulated H-S responses for that session. In order to test the extreme case for systematic cross-session changes in initial response level, stimulated responses during the first stimulated block for sessions 1 and 14 were compared. No significant differences were found ($p = .66$, sign test). The same test was made on the data for the last stimulated block; again, no significant change was found ($p = .34$, sign test). Since there were no systematic changes in frequency of H-S responses from the first to last 5-min. block across sessions, the median of each S's 14 scores was then taken for both the first and last stimulated blocks.

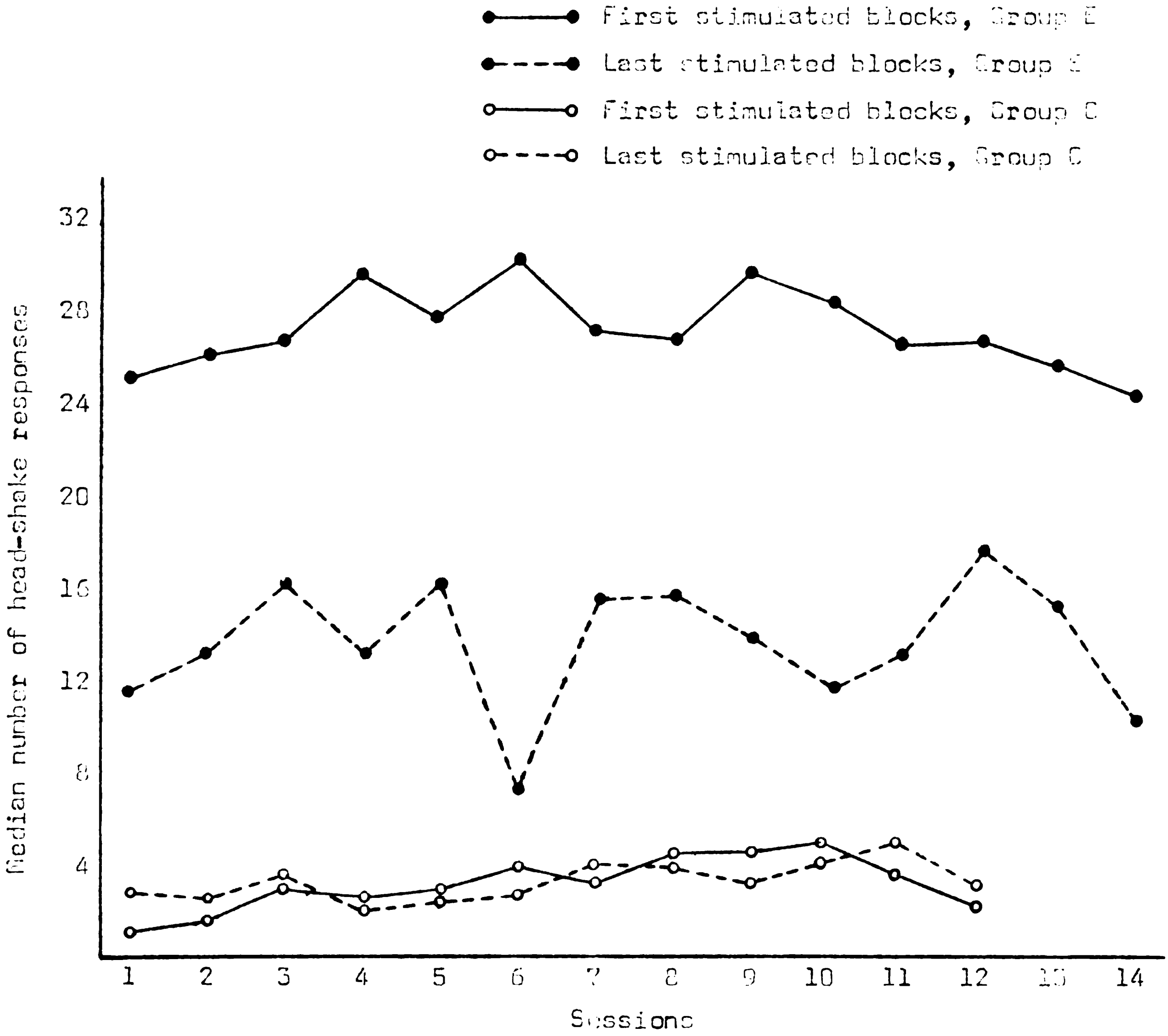

Fig. 5. Median number of stimulated head-shake responses during the first and last stimulated 5-min. blocks of each session.

The range of these median scores for the first block was 9.5-39, for the last block, 6-19.5. Out of a total of 108 cases, in only 7 was the response level at the end higher than at the first. In order to obtain an estimate of the drop in stimulated response level, the median score for the last block for each S̲ was divided by the median score for the first block. The resulting percentages ranged from 40% to 64%, with a median of 61%. Thus, using medians as the central indicators, the terminal response level was approximately 60% of the initial level.

The foregoing analysis indicated that response level during the first stimulated block does not decrease across sessions. However, the units of time involved were no finer than 5 minutes. It is possible that residual effects of prior habituation might be exhibited at a more subtle level. Therefore, the number of responses during the first stimulus presentation was investigated comparing responses on session 1 with session 12. When scores for these two sessions were compared, no significant differences were found (p = .66, sign test).

The curves for sessions 1, 7, 12 and 14 (see Fig. 3) indicate that the amount of drop in stimulated responses from the first to the second stimulated 5-min. block increased across sessions. The slope of the curve connecting these blocks becomes progressively steeper, while the portion of the curve between blocks 3 and 9 appears on sessions 12 and 14 to be approximating a straight line with a slope of zero. This suggests that response decrement within a session may have become more rapid as sessions increased. In order to test this possibility, the amount of drop between the first 2 stimulated blocks was compared with the amount of drop between the first and the last blocks. The number of H-S responses on the first block minus the number on the second block (A) was divided by the number of responses on the first block minus the number on the last block (B). The resulting ratio indicated how much of the total within-session decrement occurred between the first and second stimulated blocks. Such scores were obtained for each S̲ in Group E on each session. Since either A or B could be zero or negative, the following rules were observed in assigning scores in such cases. If A was zero or negative, a score of zero was assigned, regardless of the value of B. If A was positive but B was zero or negative, an arbitrary score of 1.0 was assigned. The scores of two male S̲s were not included in the formal analysis; one S̲ had developed an infection during sessions 8 through 11, and another had escaped prematurely on several sessions. The remaining scores were subjected to a Friedman analysis of variance (Siegel, 1956). No significant effect due to sessions was found ($X^2 = 10.84$, df = 13, $p > .50$).

In order to determine if there were systematic changes across sessions in beginning and ending base levels, comparisons (sign tests) between sessions 1 and 12 were made on the number of H-S responses occurring during the first and last 5 min. (these blocks being entirely non-stimulated). In no case were significant differences found (first 5 min.: Group E, $p = .14$, Group C, $p = .36$; last 5 min.: Group E, $p = .11$, Group C, $p = .66$). In order to make sex and group comparisons, the median of each S̲'s 12 scores was taken for the first and last 5-min. blocks respectively. U-tests were then used to compare the resulting scores. In no case were significant sex or group differences found.

Effects of reduced inter-session interval. In order to determine if the reduced interval (6 hrs.) separating sessions 12, 13 and 14 had any specific effect, a number of indices were examined. The stimulated responses for each of the three sessions were compared with sign tests. No significant differences were found (12 vs. 13, p = .64; 12 vs. 14, p = .64; 13 vs. 14, p = .36). When both beginning and ending response levels (first and last stimulated 5-min. blocks) for the 3 sessions were compared, no between-session changes were found except between the terminal levels on sessions 12 and 14 (p = .03, one-tail sign test). Finally, when percentage drop in response level (last stimulated block divided by first) was compared, no significant differences were found between sessions 12 and 13 or 13 and 14. However, the percentage drop for session 14 was significantly greater than for session 12 (p = .03, sign test).

Response decrement within 30-sec. stimulus presentations. It was observed early in the course of the experiment that, within any given 30-sec. stimulus presentation, more responses were generally given during the first 15 sec. than during the second. This relationship can be observed in Fig. 6; to obtain the data for this figure, each stimulated period for sessions 1 through 12 was split in half and the number of H-S responses counted separately. To determine if this "within-stimulus" decrement was significant, scores for the first and second halves on session 1 were compared. Significantly fewer responses occurred during the second halves than during the first (p = .03, one-tail sign test). Next, data for sessions 1 and 12 were compared to determine if changes occurred across sessions. No significant changes in response level were observed for either the first (p = .14) or second halves (p = .36, sign tests). Therefore, the median of each S's

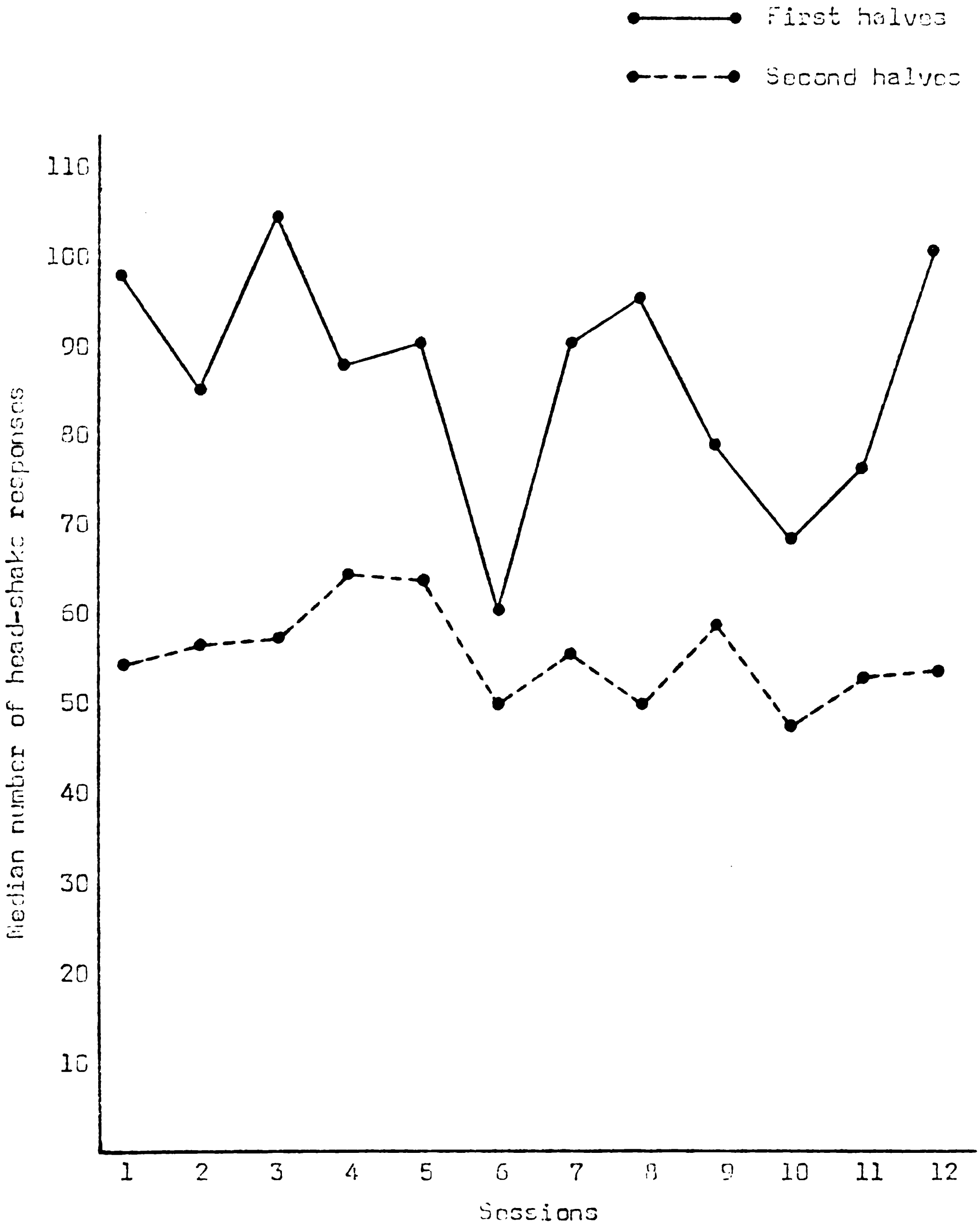

Fig. 6. Median number of stimulated head-shake responses per session (Group E) for each half of each 30-sec. stimulated period.

12 scores was taken for the first and second halves respectively. In order to compare response levels for the two halves, the median for the second halves was divided by the median for the first, resulting in a distribution of percentages ranging from 51 to 90%, median = 64.5%. Thus, the response level during the second halves of stimulated periods decreased to approximately 65% of the level during the first halves.

Temporal conditioning. Since the interval between stimulus presentations was constant, there exists the possibility that some temporal cue might have served to keep the response level higher than it would otherwise have been. That is, a high rate of responding may have become conditioned to the temporal schedule of stimulus presentation. If this were the case, it would be expected that any effects built up during stimulation would extend into the last 5 min. of the session, which were not stimulated. In addition, Ss might be expected to make more responses toward the end of each 30-sec. period separating stimulus presentations, since the time for another delivery of the stimulus was drawing near.

In order to test the first prediction, the last 5-min. blocks (non-stimulated) for each session were divided into 30-sec. periods corresponding to the schedule of stimulation established in the previous 40 min. The number of responses during "stimulated" periods (those corresponding to periods during which the stimulus had been presented) was compared with the number of responses occurring during "non-stimulated" periods. No significant differences were found for either session 1 (p = .34, sign test) or session 12 (p = .19). Since there were no differences in the extreme cases, scores were summed across the 12 sessions for each S and the resulting totals compared.

No significant difference was found between "stimulated" and non-stimulated periods (p = .36, sign test).

To test the second prediction, the 30-sec. non-stimulated periods separating stimulus presentations were divided into halves (first and last non-stimulated 5-min. blocks excluded). The number of responses in the first halves was then compared with the number occurring in the second halves. No significant differences were found for either session 1 (p = .50, sign test) or session 12 (p = .23). Again, since there were no differences in the extreme cases, scores were summed across the 12 sessions for each S and the resulting totals were compared. No significant difference between the first and second halves was found (p = .14, sign test).

Intercorrelations among head-shake response measures. In order to establish the reliability of the H-S response as a stable measure, rank-order correlations were computed between a number of the obtained measures. With N = 8, a correlation coefficient of .64 or greater is required for significance at the .05 level (Edwards, 1963).

Correlations were first calculated between responses on the pretest and session 1. On total responses for these periods, r = .12 (Group E) and r = .47 (Group C). For Group E, stimulated responses alone correlated non-significantly (r = .14); however, for non-stimulated responses alone, r = .62. For Group C, non-stimulated responses on the pretest correlated significantly with non-stimulated responses on session 1 (r = .83). When the number of responses from the first 10 min. of session 1 were considered for Group E, the correlation with total responses on the pretest did not increase a great deal (r = .31).

Rank-order correlations were next calculated between total numbers of H-S responses for all possible combinations of sessions. Tables 1 and 2 present these coefficients for Groups E and C respectively. It should be noted that, for Group E, correlations involving sessions 8 through 11 are based on an N of 7, since scores of one S for these sessions were discarded. With N = 7, an r of .68 or greater is needed for significance. The range of r's for Group E was .23 to 1.00; for Group C, it was .38 to 1.00. For Group E, only 18 out of 91 correlations were not significant (i.e., below .64 or .68). For Group C, 14 out of 66 were not significant.

Three remaining response measures were correlated for Group E: non-stimulated response level, stimulated response level, and percentage drop in response level within sessions. Scores for the first two measures were obtained by taking the median of each S's 14 scores. For the third measure, percent drop scores derived earlier under the section "Changes across sessions" were used. Base rate (non-stimulated) and stimulated response levels were not correlated (r = 0). Base rate level and percent drop were significantly correlated (r = -.71). However, stimulated response levels did not correlate significantly with percent drop (r = .10).

Frequencies of behaviors preceding and following head-shake responses

It became apparent in the early stages of the experiment that H-S responses usually did not occur when the animal was inactive. In an attempt to discover if there were certain patterns of activity within which H-S responses occurred, the behaviors which preceded and followed H-S responses were examined for sessions 1 and 12. For each response which occurred, preceding and following behaviors were recorded (frequencies only) according to the following categories: head movement,

Table 1. Intercorrelations (rank-order) among total head-shake responses per session, Group E.

Sessions	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.72	.72	.82	.71	.35	.75	.81	.52	.69	.71	.94	.70	.73
2		.83	.78	.74	.23	.74	.86	.93	.36	.82	.71	.78	.83
3			.88	.90	.37	.86	.96	.82	.82	.82	.86	.80	.74
4				.90	.60	.98	.93	.86	.71	.96	.83	.92	.91
5					.49	.91	.96	.82	.61	.93	.78	.92	.86
6						.64	.43	.50	.93	.61	.31	.62	.55
7							.93	.86	.71	.96	.76	.97	.93
8								.86	.54	.86	.89	.85	.86
9									.50	.93	.61	.88	.89
10										.68	.54	.67	.68
11											.64	.99	1.00
12												.66	.64
13													.97

Table 2. Intercorrelations (rank-order) among total head-shake responses per session, Group C.

Sessions	2	3	4	5	6	7	8	9	10	11	12
1	.85	.85	.74	.91	.78	.86	.71	.71	.74	.64	.38
2		.80	.70	.71	.57	.83	.70	.70	.79	.62	.52
3			.96	.86	.65	.60	.65	.65	.61	.65	.41
4				.86	.74	.62	.69	.69	.64	.76	.62
5					.88	.81	.81	.81	.76	.74	.52
6						.88	.91	.91	.86	.91	.67
7							.91	.91	.95	.83	.62
8								1.00	.98	.93	.61
9									.98	.93	.61
10										.91	.62
11											.71

gnashing, head movement plus gnashing, washing, and inactivity. Turning around was not included because of its infrequent occurrence. The category of head movement plus gnashing was included because in many cases the two overlapped or were in such close temporal sequence that it was difficult to determine which came first or which was predominant. There were occasional cases of overlap involving other combinations of behaviors (e.g., head movement plus washing), but these were so infrequent that placing them in separate categories would have added nothing to the analysis. These latter cases were recorded under the category of the behavior which was predominant or was temporally closer to the H-S response. That is, the categories were mutually exclusive: each instance was recorded under one and only one category. Cases where a recorded behavior did not occur within 3-4 sec. of a H-S response were recorded as "inactivity". However, the 3-4 sec. criterion was used only as a general guideline; it was usually possible to establish a "normal" pattern for each S, which was then used as the criterion.

Preceding and following behaviors were examined separately for stimulated and non-stimulated periods for Group E. Final scores were derived for each S by dividing the number of cases in each category by the total number of cases, resulting in percentages. Each S in Group E, then, produced four scores for each category, corresponding to preceding and following behaviors for stimulated and non-stimulated periods. Ss in Group C produced only two scores - for preceding and following behaviors. These scores are summarized in Table 3.

It can be seen from Table 3 that the predominant behavior preceding H-S responses was head movement; this applied to sessions 1 and 12 for both groups. The least frequent preceding behavior was washing.

Table 3. Behaviors preceding and following head-shake responses for sessions 1 and 12 (percentage scores).

Preceding behaviors

	Experimental Group								Control Group			
	Stim'd Periods				Non-Stim'd Periods							
	Session 1		Session 12		Session 1		Session 12		Session 1		Session 12	
Behavior	Range	Mdn	Range	Mdn	Range	Mdn	Range	Mdn	Range	Mdn	Range	Mdn
Head movement	24-82	47	18-67	36	44-75	62	26-85	60	49-68	61	13-79	71
Gnashing	4-22	15	6-24	8	3-19	11	0-19	5	0-13	11	0-30	5
Head mvt & Gnash	6-21	9	3-30	13	6-24	12	10-37	22	9-33	16	7-55	20
Washing	0-16	1	0-6	3	0-15	0	0-29	3	0-15	0	0-9	1
Inactiv.	8-55	24	13-62	23	0-31	7	0-15	6	0-25	4	0-23	1

Following behaviors

Head movement	31-87	57	18-68	36	20-82	57	21-56	33	11-66	48	12-38	27
Gnashing	2-22	9	2-37	11	6-33	10	10-38	26	7-54	21	0-60	28
Head mvt & Gnash	9-34	19	19-56	35	9-28	17	15-43	21	12-42	21	18-38	26
Washing	0-18	1	0-6	3	0-24	0	3-18	6	0-21	0	0-16	3
Inactiv.	2-28	8	4-13	9	0-19	10	0-15	7	0-24	5	0-21	7

The predominant behavior following H-S responses for session 1 was head movement; however, there appeared to be no predominant following behavior on session 12. The least frequent following behavior, in general, was washing. Within-group comparisons were made using sign tests to determine if significant differences existed between sessions 1 and 12. None of these comparisons revealed a significant difference. U-tests were then used to compare Groups E and C. Only one significant difference was found: the percentage of H-S responses preceded by inactivity on session 12 (stimulated periods) was lower for Group C than for Group E ($U = 4$, $p = .002$).

In spite of the group trends, considerable individual differences were apparent. No animal appeared to respond in an extremely rigid pattern; the highest proportion of responses accounted for by any one behavior for a single S was 85%. At the other extreme, the highest proportion of responses accounted for by a single behavior was as low as 33% in a few cases. Thus, while a single behavior category dominated preceding and following behaviors for a few Ss, in most cases there was substantial variability.

Durations of behaviors, other than head-shake, during sessions 1 and 12

The remaining behaviors which were recorded will be dealt with in the following order: head movement, gnashing, washing and turning around. All behaviors during sessions 1 and 12 were examined. These sessions were chosen as representing the extreme cases. Scores (ranges and medians) for these two sessions on all behaviors except turning around appear in Table 4. Scores for turning around were excluded from Table 4 because they reflected discrete occurrences. All other scores represent durations rather than discrete occurrences, since the associated beha-

Table 4. Amount of time (in sec.) spent moving the head, gnashing, and washing, sessions 1 and 12.

	Experimental Group				Control Group			
	Session 1		Session 12		Session 1		Session 12	
Behavior	Range	Mdn	Range	Mdn	Range	Mdn	Range	Mdn
Head movement	171-1265	625	185-1082	333	178-539	420	160-667	342
Gnashing	225-554	305	137-824	301	298-548	412	220-2219	286
Washing	42-357	223	22-231	142	61-251	150	59-250	148

viors generally lasted several seconds or longer.

Head movement. Ranges and medians of the scores for this response measure appear in Table 4. Significant sex differences (indicated by U-tests) were found in only two cases. In Group E, scores for stimulated periods of session 12 were higher for females than males (_U_ = 0, p = .028). And in Group C, scores on session 1 were higher for females than males (_U_ = 0, p = .028). In order to determine if head movement decreased within a session, the scores for the first stimulated period were compared (sign tests) with those from the last stimulated period. No significant differences were found in any of the comparisons. For Group E on both sessions 1 and 12 significantly more time was spent moving the head during stimulated periods than during non-stimulated periods (both sessions, p = .004, sign tests). On session 1, Group E spent significantly more time moving the head during stimulated periods than Group C (_U_ = 13, p = .025); there was no difference, however, for non-stimulated periods (_U_ = 31, p = .48). By session 12 there were no significant differences between groups. When session 1 was compared with session 12, no significant changes were found for either group. Head movement during the two sessions was not highly correlated for either group (Group E, r = -.60; Group C, r = .45).

Gnashing. The scores for gnashing are summarized also in Table 4. No significant differences between sexes were found. Scores for the first and last stimulated periods of each session were compared to determine if gnashing decreased or increased within a session. No significant differences were found. On both sessions 1 and 12, Group E spent significantly more time gnashing during stimulated periods than during non-stimulated periods (session 1, p = .03; session 12, p = .004;

sign tests). There was no significant difference between Groups E and C during stimulated periods of session 1 (U = 19, p = .10); however, scores during non-stimulated periods of session 1 were significantly lower for Group E than for Group C (U = 9, p = .007). By session 12 there were no significant differences between groups, although for non-stimulated periods the difference nearly reached significance (U = 17, p = .065). Comparing session 1 with 12 revealed no significant changes for either group. In terms of total amount of time spent gnashing, session 1 did not correlate highly with session 12 (Group E, r = -.40; Group C, r = -.26).

Washing. Ranges for amount of time spent washing on session 1 and 12 are presented in Table 4, as are medians. Significant sex differences occurred in only one case. Control males washed more than females on session 12 (U = 0, p = .028). To determine if washing decreased within a session, scores for the first and last stimulated periods were compared. No significant differences were found for Group E. However, scores for Group C decreased significantly on both sessions 1 and 12 (session 1, p = .008; session 12, p = .016). On neither session 1 nor 12 did Group E spend significantly more time washing during stimulated periods than during non-stimulated periods (session 1, p = .14; session 12, p = .36; sign tests). There were no significant differences between Groups E and C on stimulated or non-stimulated periods for either session 1 or 12. When session 1 was compared with session 12 (sign tests), no significant changes were found for either group. In terms of total amount of time spent washing, session 1 did not correlate highly with session 12 (Group E, r = .29; Group C, r = .48).

Turning around. Subjects turned around relatively few times on the test stand. For Group E, the range on session 1 was 0-32 (median, 7.5); for Group C, the range was 0-4 (median = 2). Scores for session 12 ranged from 0-4 (median = 0) for Group E, and from 0-9 (median = 2) for Group C. There were no significant sex differences for either group. On neither session 1 nor 12 did *S*s in Group E turn around more times during stimulated than non-stimulated periods (sign tests). Between-group comparisons indicated that total scores on session 1 were higher for Group E than Group C (*U* = 11, p = .014), but there was no difference on session 12 (*U* = 19, p = .10). Between-session comparisons indicated a significant decrease from session 1 to 12 for Group E (p = .008, sign test) but not for Group C (p = .50).

Intercorrelations among behavioral measures

Rank-order correlations among the various scores (totals) on sessions 1 and 12 were computed primarily for descriptive purposes. Turning around was not included here because of its extremely low frequency of occurrence. The correlation coefficients appear in Table 5. Of particular relevance are the correlations between H-S responses and the other behavioral measures. These correlations range from -.52 to .42 for Group E, from -.43 to .48 for Group C. None of the coefficients in Table 5 indicate more than a low or moderate degree of correlation between any of the measures involved.

Table 5. Intercorrelations (rank-order) among behavioral measures, sessions 1 and 12.

Session 1

	Experimental Group			Control Group		
Behavior	Head mvt	Gnashing	Washing	Head mvt	Gnashing	Washing
Head-shake	.42	.01	-.34	.31	-.43	-.10
Head mvt		-.48	-.07		.02	-.57
Gnashing			.57			-.12

Session 12

Head-shake	-.52	.31	-.12	-.10	.48	-.17
Head mvt		-.57	.29		-.15	.26
Gnashing			.38			-.29

DISCUSSION

Head-shake responses

Response level. All Ss, both experimental and control, gave H-S responses on every session. The finding of a substantial base rate for Group C runs counter to Askew's (1966) results. It is assumed that differences in the test conditions or in the age of the subjects are responsible for the discrepancy. The animals were approximately 100 days old in Askew's study and were restrained in small wire cages, considerably restricting the animals' movements.

The fact that Ss in Group C emitted H-S responses at all is curious, since no immediate stimulus can be identified. The stimulus in this case is possibly an internal one, but why the base rate should be as high as 4-5 per min. is unclear. The biological function of the response seems apparent: the H-S response functions to remove particles of debris or living organisms (e.g., parasites) from the ear of the animal. But its function when there is apparently no foreign matter in the ear is not obvious. A useful concept to invoke here may be that of vacuum responses (Ratner and Denny, 1964), referring to the occurrence of instinctive acts when drive level is heightened and only minimal or inappropriate stimuli are present. The experimental setting may have increased the drive level of the animals, leading to the occurrence of "vacuum" head-shake responses.

There were no significant sex differences for either group on total number of responses for session 1 or on summed scores for all the sessions combined. However, when uncombined session totals were subjected to "analysis of variance", females were found to have a significantly higher response level than males in Group C. On the other hand, males in Group E had a higher response level during stimulation than females, although the difference was not significant. The finding that sex differences apparent under control conditions (females higher than males) disappear (for non-stimulated periods) or are perhaps even reversed (for stimulated periods) under test conditions must remain for the moment without explanation. It is, of course, possible that such an interaction is a unique artifact of the test situation and the H-S response or is due to sampling error.

That the H-S response level was substantially modified during application of the test stimulus is clear. The rate of responding during stimulated periods was 6 to 7 times higher than it was during non-stimulated periods. However, repeated application of the test stimulus did not influence the base rate (non-stimulated responding) of Group E; Groups E and C did not differ significantly on this measure.

Within-session decrement. Two types of decrement in H-S responses within sessions were demonstrated for Group E. The first of these occurred within each 30-sec. stimulus presentation: significantly fewer H-S responses occurred during the second 15 sec. than during the first. This "within-stimulus" response decrement took place within each 30-sec. period of stimulation, and recovered substantially during the 30-sec. non-stimulated periods separating presentations of the test stimulus. The rapid recovery time suggests that this decrement may have been due to fatigue effects.

The second type of response decrement consisted of a significant drop in the number of stimulated H-S responses from the first stimulated

5-min. block to the last for each test session. This decrease within the session appeared to follow a negatively accelerated function, generally held to be characteristic of habituatory decrement (Thompson and Spencer, 1966). The terminal number of H-S responses was approximately 60% of the initial number. While the level of responding to the test stimulus decreased within a session, the base rate (non-stimulated) remained unchanged. Thus, the response decrement appeared to be specific to the test stimulus. If fatigue of the responding mechanism had been primarily responsible for the decrement within each session, the number of base-level responses should have decreased along with the number of stimulated responses, at least during periods separating stimulus presentations. Since this did not occur (only stimulated responses decreased), fatigue can be ruled out as the cause of within-session decrement.

The results for Group C show that the base rate of the H-S response is fairly constant when no test stimulus is applied. No significant differences in the number of responses during the first and last 5-min. blocks of each session were observed for this group.

Changes across sessions. No measures of the H-S response for Group E showed systematic changes across sessions. The total number of stimulated responses per session for Group E showed no systematic changes across the 14 sessions. Initial and terminal stimulated response rates remained at approximately the same levels for all 14 sessions. In addition, the habituation curves of Group E are similar for all sessions, showing no apparent change in the course of habituation within a session. It must therefore be concluded that, under the conditions employed, habituation of the H-S response in the rat is not retained over a period of 24 hrs. Further discussion of this point will be found under a later section.

The base-rate occurrence of H-S responses is apparently quite stable. No significant changes in total number of responses for 12 consecutive sessions were found for Group C. Nor were any changes observed in non-stimulated response rates for Group E, in spite of the large numbers of responses which occurred in the presence of the test stimulus.

Effects of reduced inter-session interval. When the interval separating test sessions was reduced from 24 to 6 hrs. for Group E, some evidence for retention of habituation appeared. Specifically, the amount of decrease in the H-S response level during session 14 was significantly greater than during session 12 (the latter session preceding the first 6-hr. interval). It appeared that, with only 6 hrs. separating sessions, effects of previous habituation sessions may have begun to cumulate slightly. However, the total number of stimulated responses did not differ significantly for sessions 12, 13 or 14. Thus, significant effects were apparent only in the rate of habituation, not in the total number of responses.

Temporal conditioning. The results indicate that the fixed inter-stimulus interval did not provide a temporal cue to keep the stimulated H-S response level for Group E from decreasing across sessions. The higher rate of responding during stimulated periods did not carry over into the last 5-min. block (non-stimulated entirely). Nor did Ss make anticipatory H-S responses as the end of each 30-sec. non-stimulated period approached. Therefore, the possibility of a confounding temporal factor can be ruled out.

Intercorrelations among head-shake response measures. The correlations between total numbers of H-S responses indicate the response is a highly reliable measure. This applies in general to both Groups E and C. For Group E, correlations between session 6 and the remaining sessions on total number of H-S responses were noticeably lower than for the other sessions. The same applied to correlations between session 10 and the remaining sessions. This was due largely to the fact that two animals escaped early on each of these sessions, one after only 15 min. on session 6. Their scores were therefore spuriously low for these days, and the correlations were affected accordingly.

Base-rate and stimulated response levels for Group E were not significantly correlated. That is, Ss with high base levels did not also have high response levels to stimulation. The extent of within-session drop in stimulated responses did not correlate significantly with stimulated response levels, but the former did correlate significantly with base levels (r = -.71). In other words, for animals with high base levels, degree of within-session habituation tended to be small.

Behaviors preceding and following head-shake responses

No single, dominant pattern of behaviors preceding and following H-S responses emerged. In fact, in only a few cases was a single behavior class strongly dominant at all for a given individual. Not uncommonly, H-S responses were preceded and followed by two or even three different behaviors with about equal frequency. Nevertheless, it was clear that head movement preceded and followed H-S responses more frequently than any other behavior. The least frequent behavior associated with H-S responses was washing. No differences were found between Groups E and C with respect to behaviors preceding and following H-S responses.

Behaviors other than head-shake responses

The various behaviors measured in addition to H-S responses behaved differentially, without consistent patterns. Only scattered sex differences were observed; no systematic trend was found. The only behaviors which appeared to be affected by the test stimulus were head movement and gnashing. The Ss in Group E spent significantly more time engaged in these two behaviors during stimulated than during non-stimulated periods. This may have been due to aversive properties of the test stimulus.

There were only occasional differences between groups on any of these behaviors, and these occurred in session 1. By session 12, no significant differences between groups were to be found. Scores for the behaviors showed no significant within-session changes, except for washing in Group C. Likewise, no significant changes from session 1 to 12 occurred, except for a decrease in turning around for Group E. Finally, scores for the respective behaviors on session 1 did not correlate highly with those on session 12. The lack of consistent differences plus the low stability of the measures preclude meaningful generalizations at this time.

General comments on retention

A substantial number of studies which reported retention of habituation for 24 hrs. or longer were cited in the Introduction. The present finding that habituation of the H-S response in the rat is not retained over a period of 24 hrs. stands in apparent contradiction to these prior studies. However, it does substantiate Askew's (1966) results. That the experimental conditions were at fault seems an unlikely possibility. Each S in Group E received a total of 20 min. stimulation in relatively massed presentations on 14 consecutive occasions. Within-session decrement of the H-S response was clearly demonstrated under these conditions. Indeed, indications of retention at 6 hrs. were observed in the form of slightly faster habituation within session 14. However, the residual effects even at 6 hrs. were by no means great. The data point to the conclusion that the recovery time of the habituated H-S response in the rat is probably not greater than 6 hrs., perhaps less. This is considerably shorter than the recovery times reported for many other habituated responses.

The explanation for the apparent discrepancy may lie in the nature of the H-S response itself. Tinbergen (1951) has divided the activities of organisms into two classes - appetitive and consummatory. Ratner (in press) has suggested that these two classes of behavior are subject to differential habituation. Consummatory responses "may only show *refractory phases* (brief decrements with repeated elicitation)", while appetitive responses show longer term decrements. It is quite possible that the H-S response of the rat is a consummatory response. It apparently belongs in the broader class of care of the body surface (Scott, 1958). It appears to be quite stereotyped, a prime characteristic of consummatory responses (Ratner and Denny, 1964). However, detailed analysis would be necessary in order to establish whether or not the H-S response is truly consummatory in nature. For the moment, the possibility is advanced as a tentative explanation for the lack of long-term retention of habituation.

Another possibility presents itself in accounting for the relatively rapid recovery: the H-S response may be a simple reflex (much like the knee-jerk in humans) which becomes fatigued with repeated elicitation. However, this approach is ill-equipped to handle the fairly substantial base rate of the response when no apparent eliciting stimulus is present. In addition, it will be recalled that although the H-S response showed a decrement with repeated elicitation within a session, the base rate during non-stimulated periods remained unchanged. This seems to rule out fatigue as the mechanism responsible for the observed decrement.

Adequacy of the preparation

Species. The laboratory rat appears to be a quite adequate subject for the study of habituation. The availability and tractability of this species enhance the preparation considerably. The existence of several strains presents the possibility of within-species comparisons - a powerful, fine-grain tool of the comparative psychologist. The relatively large amount that is already known about the rat readily affords the opportunity for comparing the characteristics of habituation with those of other behavior processes. Animals 30 days of age or even younger can be studied with no difficulty, the behavioral repertoire being sufficiently extensive by this age. The difference between the sexes at this age constitute no handicap, although it is possible that differences appearing with sexual maturity would have more serious effects on the preparation.

The response. The H-S response possesses several desirable characteristics. It is apparently unlearned, easily identifiable, and of short duration. Its rate of occurrence to stimulation is relatively high, but shows definite decrement with repeated stimulation. While the response does have an above-zero base rate (at least under the conditions employed in this study), it is apparently quite stable across time. The high reliability of the response measure, for both base-level and stimulated rates, is a particularly desirable attribute. The relatively rapid recovery of the habituated response would facilitate intensive analysis of the recovery function. Finally, should further study indicate the H-S response to be consummatory in nature, it would provide a good preparation for investigating differences in habituation of appetitive and consummatory responses. Appetitive responses of the rat could certainly be identified for use in such studies.

Test stimulus. The general effectiveness of the test stimulus is demonstrated by the fact that stimulated response rates were 6 to 7 times as great as base rates. However, the test stimulus was an effective eliciting stimulus for the H-S response in only 75% of the animals initially tested. It did elicit at least a few responses even in those animals which were rejected. It is thus possible that modification of the test situation would eliminate "non-responders", although exactly what type of modification is not clear.

Pretest. The 10-min. pretest was successful as a screening measure - no non-responders were encountered during any of the test sessions. However, the H-S response measures from the pretest were of very limited value in predicting later H-S activity. Stimulated and non-stimulated response rates during the pretest were not significantly correlated with the corresponding measures on session 1 for Group E. The correlation for base-level rates for Group C was significant, indicating that later response levels were consistent with those on the pretest.

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APPENDIX A

Total number of head-shake responses per session for each subject.

Experimental Group

	Sessions													
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	240	183	175	212	195	185	195	186	183	197	176	188	216	175
2	165	186	153	133	131	146	175	156	200	164	158	166	152	166
3	157	155	201	186	197	185	180					170	156	148
4	240	278	245	213	271	97	227	223	209	154	186	229	220	189
5	195	202	237	255	243	189	285	207	268	186	198	187	229	210
6	201	185	212	194	189	158	178	194	197	184	156	201	146	100
7	121	80	91	90	112	116	91	121	98	91	103	112	87	88
8	73	86	99	87	78	67	68	68	65	50	70	71	87	81

Control Group

1	99	101	123	135	82	104	99	94	88	127	155	135
2	23	9	34	27	56	66	48	54	57	36	53	39
3	25	22	40	30	44	30	34	29	20	19	35	69
4	21	19	31	24	22	24	24	13	9	9	6	5
5	177	117	98	84	100	118	163	131	113	135	117	90
6	103	126	135	102	90	89	152	147	125	154	118	49
7	33	33	31	24	38	49	57	47	51	50	50	42
8	2	19	24	24	34	57	55	72	61	76	89	77

(For each group, _S_s 1-4 are males, _S_s 5-8 are females.)