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ABSTRACT

This study investigated the effects of prior experience with contingent or noncontingent stimulation of infants' ability to learn different responses to control perceptual stimulation. In the pretest phase, baseline rates of level movement, panel press and vocal responding were determined for each of the twelve, 6-month-old infants in the study. During treatment sessions, subjects assigned to the contingent stimulation group controlled presentation of auditory-visual stimulation by manipulating a level. An equal number of subjects assigned to the noncontingent stimulation group received the same stimulation noncontingently. In the posttest phase, all subjects were observed in separate tests of (1) learning to panel press, and (2) learning to vocalize to control perceptual stimulus presentation. Results indicate that the long-term effect of prior contingent stimulation is to enhance responding to control environmental stimulation. In contrast, prior experience with noncontingent stimulation interferes with learning to control environmental stimulation. Analyses of attentional behaviors were used to suggest the processes by which previous experience with contingent and noncontingent stimulation influenced subsequent learning to control stimulation. (Author/ED)

LEARNING TO CONTROL ENVIRONMENTAL STIMULATION IN INFANCY

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One important part of an infant's competence is his ability to control influential aspects of his environment such as the care giving behaviors of adults and sensory stimulation from objects. (Ainsworth & Bell, 1973; White, 1959).

There is some research suggesting that the extent to which stimulation is contingent upon or independent of the subject's behaviors, can have long term effects on the development of competence in general, and learning to control environmental effects in particular. Non-contingent stimulation has been observed to interfere with subsequent learning to control the same kind of stimulation for dogs (Seligman & Maier, 1967), rats (McCullock & Bruner, 1939), human adults (Thornton & Jacobs, 1971), and children (Dweck & Repucci, 1973; Watson, 1971). There is also evidence that infants' previous experience with contingent stimulation is positively related to 1) performance on infant intelligence scales (Yarrow, Rubenstein, Pedersen, & Jankowski, 1972), 2) learning ability in an habituation paradigm (Lewis & Goldberg, 1969), and 3) learning to control sensory stimulation (Ramey, Starr, Pallas, Whitten & Reed, 1975; Watson, 1971).

This report describes a study performed to test these hypotheses: first, that prior experience with contingent stimulation would enhance learning different responses to control perceptual stimulation; and second, that prior experience with noncontingent stimulation would interfere with learning these same behaviors.

We were also interested in the processes by which experiences with contingent and noncontingent stimulation modify subsequent learning ability. The available literature (Horowitz, Paden, Bhana and Self, 1972; Millar, 1972; Watson, 1971) led us to hypothesize that infants whose behaviors controlled stimulus presentation would pay more attention to the stimulation and also to responses they performed to produce the stimulation than infants who received the same stimulation noncontingently. We also expected that these differences in attentional behaviors would transfer to subsequent learning situations mediating predicted differences in learning to control stimulus presentation.

Design

In the pretest phase baseline rates of lever movement, panel press and vocal responding were determined. During the treatments sessions, subjects assigned to the contingent stimulation group (Group C) controlled presentation of auditory-visual stimulation by manipulating a lever. An equal number of subjects assigned to the noncontingent stimulation group (Group NC) received the same stimulation noncontingently. In the post-test phase all subjects were observed in separate tests of 1) learning to panel press, and 2) learning to vocalize to control perceptual stimulus presentation.

Method

Subjects

Subjects for this study were 12, 6-month old infants attending the Abecedarian Project at the Frank Porter Graham Center. These infants, who are from economically disadvantaged backgrounds, receive a special program of curriculum activities to prevent developmental delay.

Infants closest in age were paired and then assigned to treatment groups so that the groups would be similar in mean baseline rate of lever responding. Each group consisted of four black male and two black female infants, all of whom scored within the normal range on the Bayley Scales of Infant Development at 6 months of age.

Procedure

Insert Figure 1 about here

During the lever response sessions, subjects sat 35-40 cm from a white projection screen on the lap of an assistant who held the lever manipulandum as illustrated in Figure 1. An audio-speaker was placed at the base of the screen. Moving the lever on the top of the box in any direction was defined as a response. Baseline lever response rate was determined from a 6-minute period during which no stimulation was presented.

Insert Figure 2 about here

As illustrated in Figure 2, during the panel press response sessions, subjects were seated 35-40 cm from the apparatus on the lap of an assistant who held the panel manipulandum. A screen was located in the center of the apparatus, and a speaker was placed under the table. Depressing a panel at the top of the box defined a response.

Insert Figure 3 about here

Vocal response sessions occurred in the same setting as the panel press response sessions (see Figure 3). Panel press and vocal response baselines were determined simultaneously from a 6-minute period in which no stimulation was presented. Vocal responses during the baseline session were coded from videotapes and observer agreement was 83%. The order of lever response baseline and panel press-vocal response baseline sessions was counterbalanced across pairs of subjects.

Treatment

Following the baseline phase, subjects received two, 6-minute lever response treatment sessions on each of 3 consecutive days. Each lever response session was divided into three, 2-minute periods.

Group C. In each treatment session, subjects in Group C received two contingent stimulation periods and one extinction period in random order. Discrimination training was incorporated to provide a within group control to test for lever response learning. A slide of a yellow toy dog was displayed on the screen throughout the contingent stimulation periods. During contingent stimulation periods, lever responses produced 2-second presentations of a slide of a red parallellogram and simultaneous vocal-instrumental music on a FI, 2-second schedule. In the extinction period the toy dog slide was removed from the screen, and lever responses were not reinforced.

Group NC. In each treatment session subjects in Group NC received two periods of noncontingent stimulation and one period of no stimulation in the order corresponding to contingent stimulation and extinction periods, respectively, received by their Group C pairmates. The slide of the toy dog signaled noncontingent stimulation periods during which Group NC subjects were presented noncontingently the same temporal pattern of auditory-visual stimulation received by their Group C pair-mate in the corresponding session. The toy dog slide was removed from the screen during the no stimulation period.

Posttests

Effects of prior contingent and noncontingent stimulation were studied in two posttest situations involving learning new responses to control stimulus presentation. Each learning situation consisted of two, 6-minute sessions. The different situations were each presented on separate days in counterbalanced order across pairs of subjects.

Panel Press Response Posttest. In one learning task, panel press responses produced 2-second presentations of the same auditory-visual stimulation used in the treatment sessions on an FI, 2-second schedule for both groups of subjects.

Vocal Response Posttest. In the other posttest learning task, vocal responses produced 2-second presentations of the toy dog slide, previously presented in treatment sessions, for both groups of subjects. During vocal response sessions, two observers independently coded vocal responses. When both simultaneously coded a vocal response, stimulation was presented on an FI, 2-second schedule.

All sessions were videotaped. Observations of the behavior "looking at the stimulus display screen" were coded from videotapes of the lever, panel press and vocal response sessions. Observations of the behaviors "looking at the lever manipulandum" and "looking at the panel manipulandum" were coded from videotapes of lever response and panel press response sessions, respectively. Two observers independently coded the videotapes of one third of the lever responses sessions and one half of the panel press and vocal response sessions for each subject. Observer agreement was defined as both observers coding the onset of the same behavior within

2 seconds of each other. Percent agreement was computed by dividing the number of agreements by the number of agreements plus disagreements. Observer agreement for looking at the screen responses was 82%. Observer agreement for looking at the manipulanda responses was 79%.

Data Analysis and Results

Lever Response Sessions

Frequency measures for behaviors observed in the lever response sessions were combined for the two sessions on each day. Frequencies were then converted to per minute rates for the contingent stimulation (C) and extinction (Ext) periods for Group C, and for the noncontingent stimulation (NC) and no stimulation (NS) periods for Group NC.

Response rates for each behavior were separately analyzed using the multivariate analysis of variance (MANOVA) for repeated measures designs (McCall & Appelbaum, 1973). In each analysis differences between Group C and Group NC were tested separately for the baseline day and for the treatment days (i.e., days on which contingent or noncontingent stimulation was presented). This strategy was employed because it was predicted that Group C would have higher scores than Group NC on all of the behaviors observed during treatment and posttest sessions. However, it was also expected that the groups would not differ in response rates for any behavior observed during baseline sessions.

In the analysis of variance, main effect tests for factors with only two levels are equivalent to *t* tests. Therefore, it was possible to use one-tailed tests where directional hypotheses were stated. However, it was believed that sizeable differences in the direction opposite to that predicted should not be ignored. Since the use of one-tailed tests precludes consideration of the significance of differences in the opposite direction, we decided to use a two-tailed test in which more of the region for rejecting the null hypothesis (90%) was in the tail corresponding to the predicted direction of difference. Thus, large differences in the opposite direction would not be overlooked or go unnoticed. Still the overall probability of a Type I error was 5%. The "unequal", two tailed tests were performed for tests of group differences during treatment and posttest sessions and for contingent stimulation vs. extinction period differences in treatment sessions for Group C. Since the frequency of the behaviors observed were not expected to differ in noncontingent and no stimulation periods of the treatment sessions, no directional hypotheses were tested for Group NC.

Insert Figure 4 about here

The analysis of lever response rate indicated that only infants in Group C, whose behavior controlled stimulus presentation increased in lever response rate. As can be seen in Figure 4, presentation of noncontingent stimulation to Group NC did not produce a sustained increase in lever responding. The Groups X Days interaction was significant, F (3,8) = 4.898, $p < .05$, and was analyzed with simple main effect tests. Group C and Group NC did not differ in lever response rate during baseline. However, Group C responded at a significantly greater rate than Group NC on treatment days, F (1,10) = 11.326, $p < .05$. Only Group C increased in lever response rate from baseline to treatment days, F (3,8) = 8.962, $p < .05$. The short-lived increase in lever response rate for Group NC was not significant. Further, Group C responded more frequently in contingent stimulation periods than in extinction periods,

F (1,10) = 4.712, $p < .05$. Group NC did not respond at different rates in the noncontingent and no stimulation periods.

Panel Press Response Posttest

Per minute rates for each behavior observed in the panel press response sessions were separately analyzed with MANOVA procedures in a 2 (Groups) X 3 (Sessions) repeated measures design.

Insert Figure 5 about here

The analysis of panel press response rates, which are presented in Figure 5, indicated that neither group learned to perform this response to control stimulus presentation. Group C and Group NC did not differ in panel press response rate in either baseline or posttest sessions, and neither group increased in response rate across sessions.

Vocal Response Posttest

Per minute response rates for behaviors observed in the vocal response posttest sessions were separately analyzed using the MANOVA procedures in a 2 (Groups) X 3 (Sessions) repeated measures design.

Insert Figure 6 about here

The analysis of vocal response rates, which are illustrated in Figure 6, indicated that only Group C learned to control stimulus presentation using the vocal response. A significant Groups X Sessions interaction, F (2,9) = 7.657 $p < .05$, was analyzed with simple main effect tests. Group C responded at a reliably greater rate than Group NC only in the second posttest session, F (1,10) = 54.97, $p < .05$.

Further, only infants in Group C reliably increased in vocal response rate from baseline to posttest sessions, $F\ (2,9) = 20.912$, $p < .05$. The increase in vocal response rate for Group NC from baseline to the posttest sessions was not reliable.

Insert Figure 7 about here

Looking at the Screen Responses

The analysis of looking at the screen responses indicated that both groups were attending to the stimulation presented in the treatment sessions. Rates of looking at the screen, illustrated in Figure 7, did not reliably differ between Group C and Group NC on either baseline or treatment days. The periods main effect was significant, $F\ (1,10) = 40.312$, $p < .05$, showing that both groups looked at the screen more frequently during the contingent and noncontingent periods than during the extinction and no stimulation periods. The days main effect, $F\ (3,8) = 15.641$, $p < .05$, and the Days X Periods interaction, $F\ (3,8) = 11.083$, $p < .05$, were both reliable. Simple main effect tests for Days within Periods revealed a significant increase in frequency of looking at the screen only with the contingent and noncontingent stimulation periods, $F\ (3,8) = 14.737$, $p < .05$. In sum, the rate of looking at the screen responses in lever response sessions was greatest at the times when either contingent or noncontingent stimulation was presented. This suggested subjects in both groups were attending to the stimulation presented.

The analysis of the rates of looking at the screen responses in the panel press response sessions, which are illustrated in Figure 7, also suggested that both groups of subjects were attending to the stimulation presented. Group C and Group NC did not reliably differ in response rate in either the baseline or posttest sessions. The sessions main effect was significant, F (2,9) = 14.068, $p < .05$, and the Groups X Sessions interaction was not reliable. Thus, both groups increased in rate of looking at the screen responses from baseline to panel press response posttest sessions.

Rates of looking at the screen in vocal response sessions are also presented in Figure 7. The data analysis revealed a significant Groups X Sessions interaction, F (2,9) = 6.800, $p < .05$. Simple main effect tests for Groups within Sessions and for Sessions within Groups were performed to clarify the nature of this interaction. Group C and Group NC did not differ in response rate in either the baseline or first posttest sessions. In the second posttest session, subjects in Group C looked at the screen more frequently than subjects in Group NC, F (1,10) = 9.02, $p < .05$. Significant sessions effects were found within both Group C, F (2,9) = 53.244, $p < .05$, and Group NC, F (2,9) = 18.841, $p < .05$. As can be seen in Figure 7, infants in Group C showed an increase in frequency of looking at the screen from baseline to the first posttest session and a smaller increase from the first to the second posttest session. Infants in Group NC increased in frequency of looking at the screen from baseline to the first posttest session and then decreased in response frequency from the first to the second posttest session.

<u>Looking at the Manipulanda Responses</u>

Observations of looking at the manipulanda behaviors were not begun until the behavior of the first two subjects in the treatment and panel press response posttest sessions revealed the importance of this behavior. Two observers independently noticed that the infant who received contingent stimulation paid much more attention to the lever and panel manipulanda than the infant who received noncontingent stimulation. This difference in attention to the manipulanda seemed to be a plausible consequence of the treatment procedures, and its occurrence had been suggested by Millar (1972). When recording of looking at manipulanda responses was begun, two more subjects had already been observed in the baseline sessions. Missing data were distributed equally in Group C and Group NC. A way to use all of the data available was to compare group differences during the baseline sessions using the data from 8 infants separately from comparison of group differences in treatment and posttest session which were made using the data from 10 infants. In addition, in analyses of looking at the lever manipulandum, main effect and interaction tests for the days factor were performed for baseline and Day 1 using the data from 8 infants. A second set of tests were performed for the data from 10 infants on Days 1, 2, and 3. Similarly, in analyses of looking at the panel manipulandum, one set of tests for the sessions main effect and interactions with the sessions factor were performed for the data from 8 infants in the baseline and first posttest session. A second set of tests on the sessions factor was performed for the data from 10 infants in the 2 posttest sessions.

Insert Figure 8 about here

The analysis of rates of looking at the lever manipulandum, which are presented in Figure 8, suggested that attending to the lever manipulandum was related to learning to control stimulus presentation.

Group C and Group NC did not differ in frequency of looking at the lever on the baseline day. During treatment days, subjects in Group C looked at the lever manipulandum more frequently than subjects in Group NC, $F\ (1,8) = 3.821\ p < .05$. The Groups X Periods interaction approached significance, $F\ (1,8) = 4.463$, $p < .07$. Since it was predicted that the Groups would differ in attending to the lever manipulandum only for comparisons of the contingent and noncontingent stimulation period, this simple effect was tested a priori. The results indicated that Group C looked at the lever more frequently than Group NC, $F\ (1,11) = 15.38$, $p < .05$, only in comparison of contingent and noncontingent stimulation periods. The groups did not differ in frequency of looking at the lever manipulandum when compared within the extinction and no stimulation periods. The prediction that infants in Group C would look at the lever manipulandum more frequently during the contingent stimlation period than during the extinction period was confirmed, $F\ (1,8) = 23.809$, $p < .05$, in an a priori test.

The tests of the days effects using baseline and Day 1 data only, revealed a significant Day X Periods interaction, $F\ (3,4) = 10.814$, $p < .05$. Simple main effects tests for Days within Periods indicated that looking at the manipulandum increased from baseline to Day 1 within the contingent and noncontingent stimulation periods, $F\ (1,6) = 12.219$, $p < .05$, but not within the extinction and no stimulation periods.

Analysis of the days effects for Day 1 to 3 (treatment days only) showed a reliable days main effect, $F\ (2,7) = 11.836\ p < .05$. This result reflected a decline in frequency of looking at the lever manipulandum from Day 1 to 3 for both groups. Looking at the lever manipulandum occurred most frequently for Group C and particularly during the contingent stimulation period. This suggests that attending to the lever manipulandum was related to learning to control stimulus presentation.

Rates of looking at the panel manipulandum are presented in Figure 8. Group C and Group NC did not differ in frequency of looking at the panel manipulandum during the baseline session. However, during the posttest sessions, infants in Group C looked at the panel more frequently than infants in Group NC, F (1,8) = 3.778, $p < .05$. Tests of the sessions main effect and Group X Sessions interaction were not significant.

Discussion

The data from the posttest learning situations showed that only subjects in Group C, who had previous experience with contingent stimulation (in the lever response sessions learned to perform a new response to control stimulus presentations. Subjects in Group NC, as predicted, did not learn to panel press or vocalize to control stimulus presentation in the posttest phase. Subjects in Group C learned only the vocal response to control presentation of the toy dog slide.

Infants in Group C might not have performed the panel press response because they were habituated or satiated to the auditory-visual stimulation which panel press responses controlled. The auditory-visual stimulation, which consisted of a picture of a red parallelogram and children's songs, was presented contingently to subjects in Group C in both treatment and panel press response posttest sessions. These infants were able to control presentation of the toy dog slide for the first time in the vocal response session which could have made the vocal learning situation more novel than the panel press response situation.

The difference in responding to control stimulation in the vocal and panel press response sessions observed in Group C is consistent with other findings that exploratory and manipulatory behaviors decline with increasing stimulus familiarity (Hutt, 1967; Rheingold, Stanley, and Doyle, 1963; Welker, 1956).

The data from this study support the contention that the effects of previous experience with contingent and noncontingent stimulation are not limited to a single response. It appears that the long term effect of prior contingent stimulation is to enhance subsequent responding to control environmental stimulation. In contrast, prior experience with noncontingent stimulation interferes with learning to control environmental stimulation.

A second major question concerned the processes by which previous experience with contingent and noncontingent stimulation influenced subsequent learning to control stimulation. This question was addressed by analyses of attentional behaviors. Attention to stimulus presentation was indexed by frequency of looking at the stimulus display screen. Results showed that attention to the stimulus presentations was unrelated to learning to control stimulus presentations. In the treatment sessions, subjects in Group C and Group NC received the same number of stimulus presentations. Subjects receiving noncontingent stimulation were just as attentive to the stimulation as the infants in Group C who learned to control stimulus presentation. This finding is not consistent with the observations of Watson (1971) and Horowitz et al., (1972) that infants pay more attention to stimulus presentations that are response controlled than presentations that are response independent. The observation that subjects in Group C looked at the screen more frequently in the second vocal response posttest than infants in Group NC might have been due to the fact that Group C vocalized more and, therefore, received more stimulus presentations than Group NC.

Analyses of looking at the manipulanda responses provided support for Millar's (1972) speculation that noncontingent stimulation might habituate an infant's attention to his own behavior. On the other hand, contingent stimulation appears to have heightened the infant's attention to his own responses. Infants in Group C looked at the lever manipulandum more frequently than infants in Group NC, but only during the periods of each session when Group C infants could control stimulus presentation. Thus, attending to one's own behavior was related to learning to control stimulus presentation in the treatment sessions.

In the panel press responses sessions, subjects in Group C again paid more attention to their own behavior than infants in Group NC. This suggests that prior experience with contingent and noncontingent stimulation had a transfer effect on the mediating behavior of attending to one's own responses. Insofar as attending to one's responses was related to learning to control stimulus presentation, this attentional behavior might be part of the learning process. If this assumption is reasonable, it can be concluded that prior experience with contingent and noncontingent stimulation had effects on the process of learning to control stimulation presentation in the panel press response posttest.

The failure to observe a difference between Group C and Group NC on panel press response frequency cautions us that learning to control environmental stimulation in infancy is influenced by many variables. Among these variables are stimulus novelty and the infant's prior experience with contingent and noncontingent stimulation.

The most suggestive interpretation of the results of this study is that infants do more than learn a single, simple response in operant learning tasks such as those employed here. The infants who received prior contingent stimulation appeared to become more competent and efficient as learners. These infants were developing a strategy for deploying attentional responses to the key elements of many learning situations viz, the response and the response outcome.

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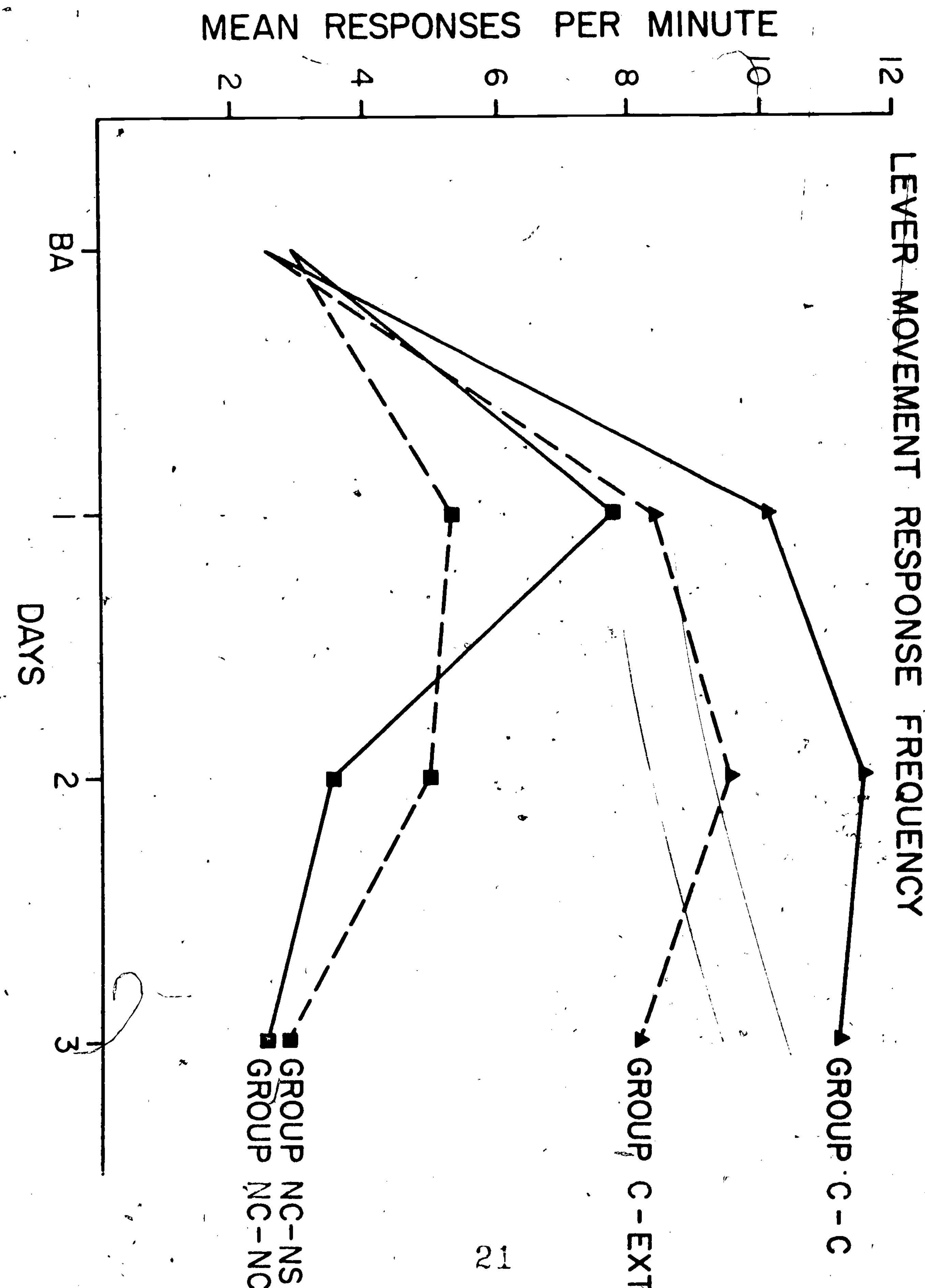
FIGURE 1
Illustration of lever response situation.

FIGURE 2
Illustration of panel press response situation.

FIGURE 3
Illustration of vocal response situation.

FIGURE 4



LEVER MOVEMENT RESPONSE FREQUENCY
MEAN RESPONSES PER MINUTE
2
4
6
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12
DAYS
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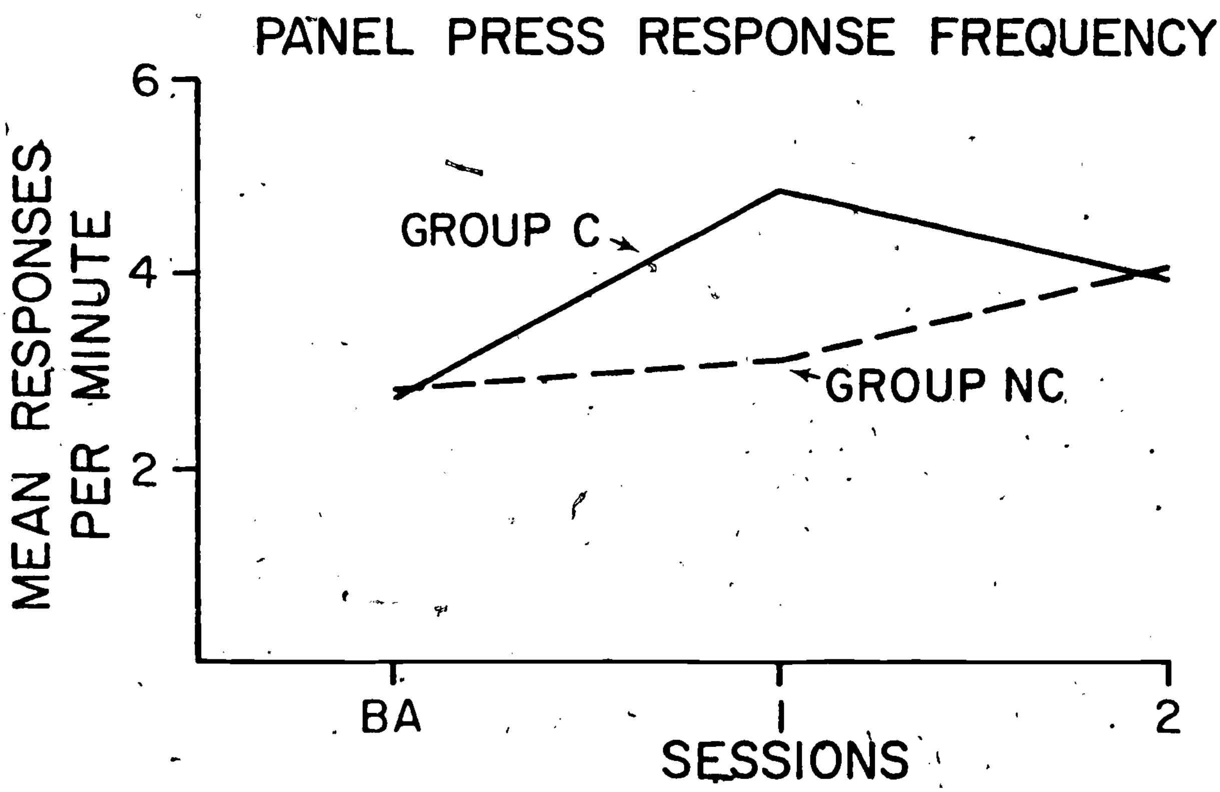
3
GROUP C-C
GROUP C-EXT
GROUP NC-NS
GROUP NC-NC

FIGURE 5


PANEL PRESS RESPONSE FREQUENCY
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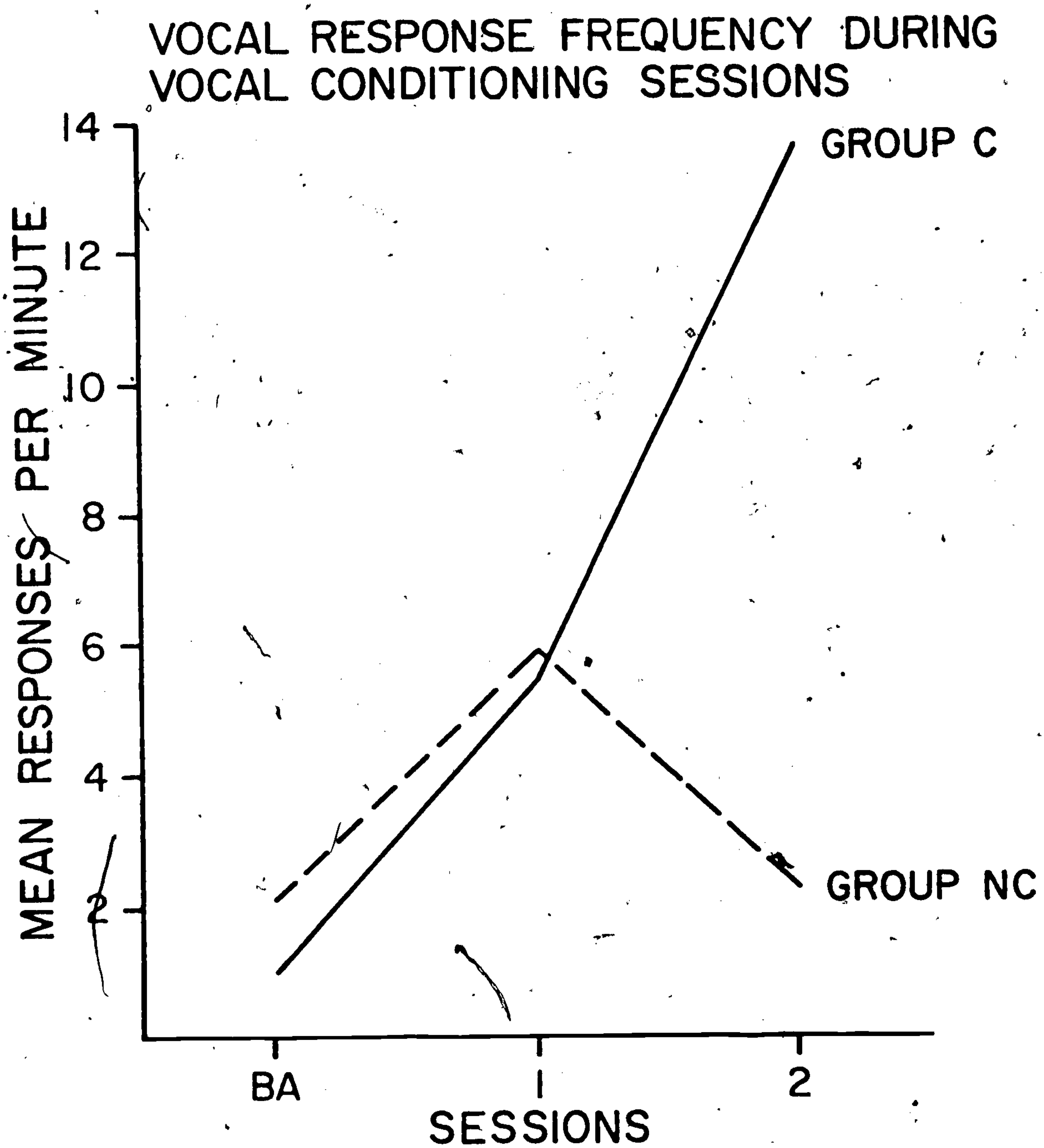
MEAN RESPONSES PER MINUTE
GROUP C
GROUP NC
BA
1
2
SESSIONS

FIGURE 6


VOCAL RESPONSE FREQUENCY DURING
VOCAL CONDITIONING SESSIONS
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MEAN RESPONSES PER MINUTE
GROUP C
GROUP NC
BA
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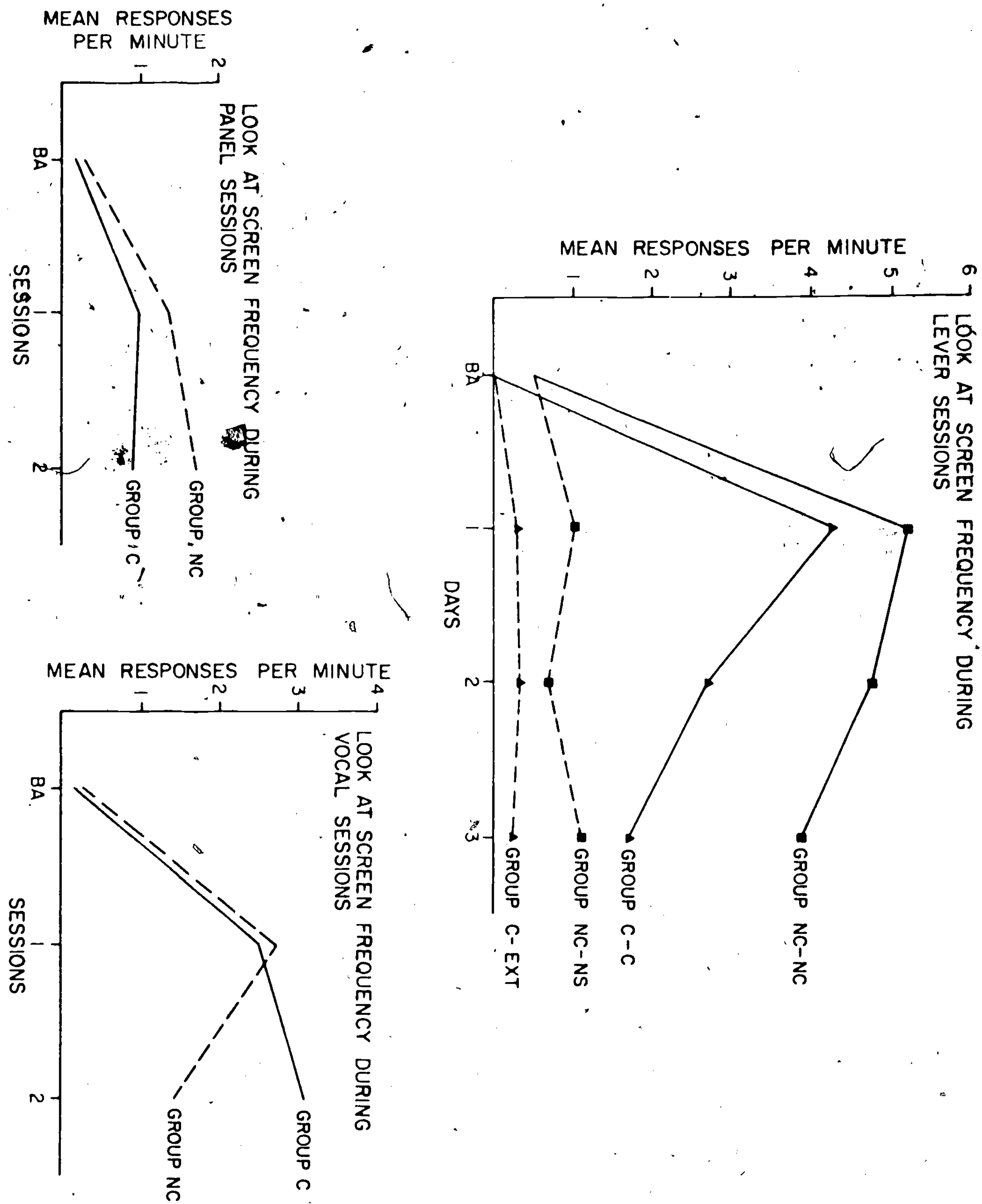
SESSIONS

FIGURE 7



LOOK AT SCREEN FREQUENCY DURING LEVER SESSIONS
MEAN RESPONSES PER MINUTE
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DAYS
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3
GROUP NC-NC
GROUP C-C
GROUP NC-NS
GROUP C-EXT
LOOK AT SCREEN FREQUENCY DURING PANEL SESSIONS
MEAN RESPONSES PER MINUTE
1
2
SESSIONS
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GROUP NC
GROUP C
LOOK AT SCREEN FREQUENCY DURING VOCAL SESSIONS
MEAN RESPONSES PER MINUTE
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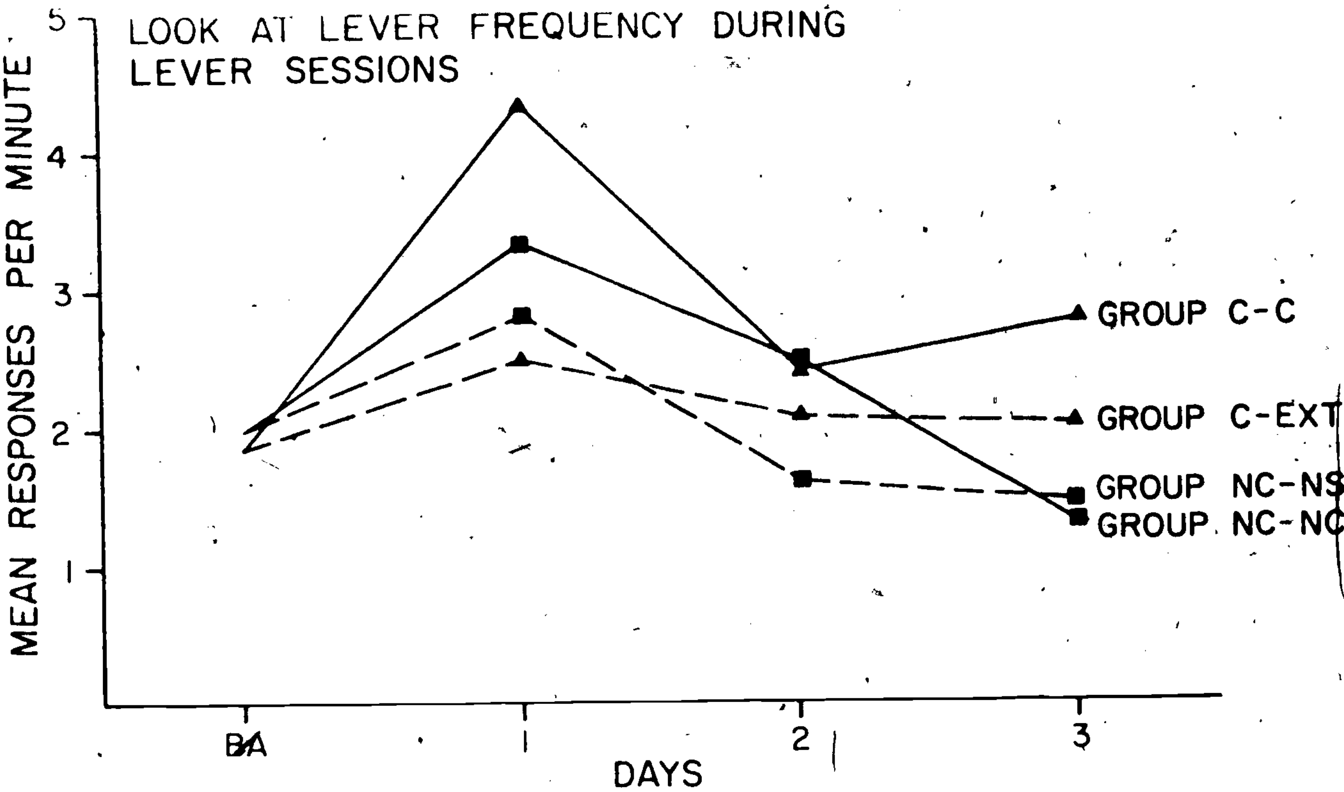
GROUP C
GROUP NC

FIGURE 8


LOOK AT LEVER FREQUENCY DURING LEVER SESSIONS
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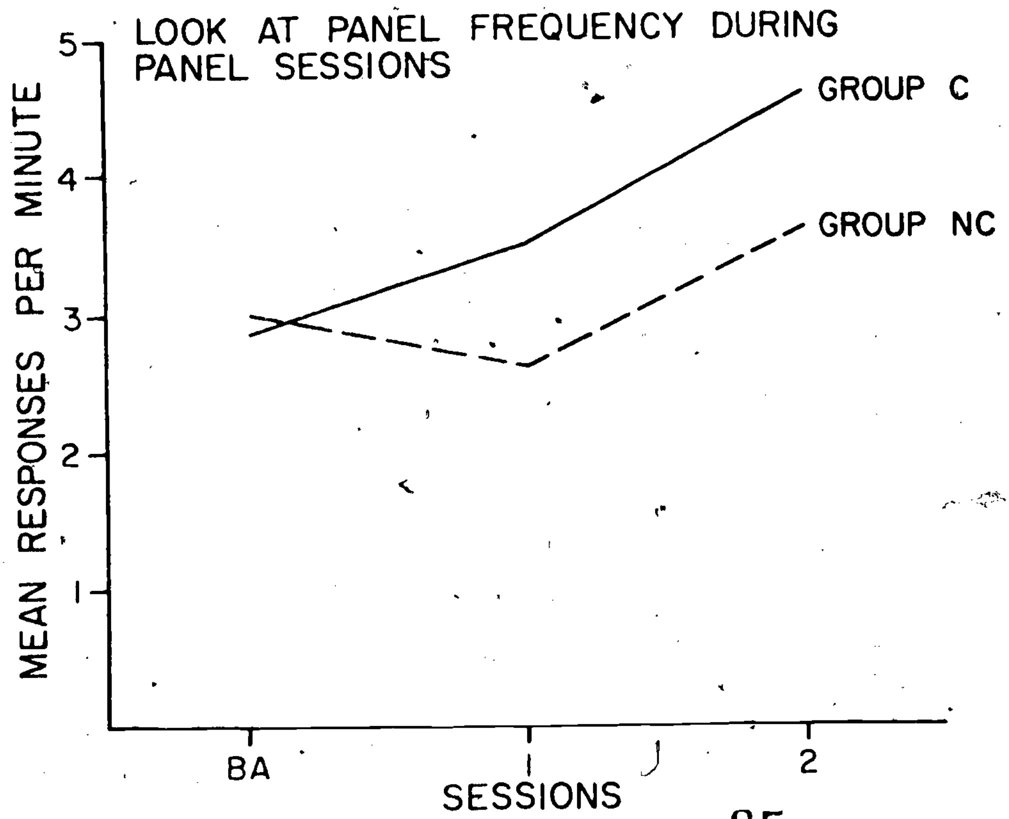
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