OPERANT CONDITIONING OF SKIN POTENTIAL IN HUMANS WITH CONTROL FOR SOMATIC MEDIATION

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY
MARGUERITE B. STEVENSON
1972

ABSTRACT

OPERANT CONDITIONING OF SKIN POTENTIAL IN HUMANS WITH CONTROL FOR SOMATIC MEDIATION

By

Marguerite B. Stevenson

The long standing distinction between the domains of operant and classical conditioning has recently been challenged by demonstration of operant conditioning of autonomic activity. Although such conditioning has been demonstrated, the possibility that the response change is mediated by a change in somatic activity has been repeatedly raised. The present study controlled for the possibility of mediation due to bilateral somatic changes by conditioning differential responding in the right and left hands. During contingent reinforcement sessions, subjects were reinforced for producing skin potential responses in one hand that were three times as large as the skin potential response seen in the other hand. Each subject received 10 daily, twenty-minute sessions. Four subjects received contingent reinforcement the first week and non-contingent (random) reinforcement the second week. This order was reversed for another group of four subjects. Results of the study indicated conditioning in some subjects in each of the groups. For the combined data for all subjects there was both a high number of criterion responses and a higher proportion of such responses during contingent reinforcement rather than during non-contingent reinforcement. Discussion focused on the problems and issues associated with operant conditioning of autonomic activity.

OPERANT CONDITIONING OF SKIN POTENTIAL IN HUMANS WITH CONTROL FOR SOMATIC MEDIATION

By

Marguerite B. Stevenson

A THESIS

Submitted to

Michigan State University

in partial fulfillment of the requirements

for the degree of

MASTER OF ARTS

Department of Psychology

1972

To Rod

ACKNOWLEDGEMENTS

This study was supported in part by NIMH Research Grant MH-MH-18655 Biomedical Sciences Support Grant and NSF-URP Grant GY-8727 to Dr. Hiram Fitzgerald.

The author would especially like to thank Dr. Fitzgerald, chairman of the thesis committee, for his advice and assistance during all phases of this study and to thank Dr. Elaine Donelson and Dr. Mark Rilling for their guidance as members of the thesis committee. Thanks are also expressed to Charles Wilson for assistance in the collection and summarization of the data as well as his advice and enthusiasm during this part of the study.

Thanks also go to the department of psychology for providing access to subjects and to the subjects for their perserverance in the difficult and frustrating task.

Special thanks go to my husband Rod for his encouragement and suggestions throughout the study as well as for his patience with the large amount of work involved.

TABLE OF CONTENTS

TABLE OF CONTENTS (con't)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (con't)

INTRODUCTION

One support of two process theory is that operant and classical conditioning can be distinguished by the responses that they modify (Rescorla & Soloman, 1967). Two process learning theorists have traditionally said that autonomic activity could be modified only by classical conditioning, somatic activity only by operant conditioning. This seemed to be a reasonable distinction since classical conditioning was said to involve involuntary, reflexive actions while operant conditioning required voluntary action. To test this assumption Skinner (1938) made an early attempt to use operant procedures to modify autonomic activity. His failure to operantly condition a vasomotor response led him to conclude that such conditioning was not possible. About the same time Mowrer (1938) made an unsuccessful attempt to operantly condition the Galvanic Skin Reflex (GSR), and Konorski and Miller (1937) wrote that they did not consider autonomic activity modifiable by any means other than classical conditioning. In the fifties and early sixties a few reassertions were made that such conditioning was impossible (Keller & Schoenfeld, 1950; Kimble, 1961; Soloman & Wynne, 1954). For many years the issue was considered settled: autonomic activity could not be modified operantly.

Then in 1961 Razran reported that in the Russian lab Lisina's subjects (Ss) had succeeded in acquiring voluntary control of vascular activity. Subjects receiving exteroceptive feedback learned vasodilation (Razran, 1961). When Lisina's work was translated into English in 1965 it was apparent that her Ss had only learned to relax their muscles and to alter their respiratory patterns rather than to directly control autonomic activity (Lisina, 1965). But by then her study had sparked a great deal of additional work in this country. About the same time as Razran's report, Kimmel and Hill (1960) posed serious difficulty for the two factor learning theory by demonstrating operant conditioning of the GSR. These pivotal studies initiated intensive investigation of the conditionability of autonomic responses using the operant methodology. Hefferline (1962) suggested the direction of this work when he reported on the presence of interoceptors in the viscera. Following the work of Kimmel & Hill (1960) many researchers have successfully demonstrated operant conditioning of electrodermal responses in adult humans (Crider, Shapiro & Tursky, 1966; Defran, Badia & Lewis, 1969; Fowler & Kimmel, 1962; Gavalas, 1967; Greene & Nielson, 1966; Greene, 1966; Johnson, 1963; Kimmel & Kimmel, 1963; Milstead, Baer & Fuhrer, 1968; Shapiro, Crider & Tursky, 1964; Shapiro & Crider, 1967; Van Twyver & Kimmel, 1966).

While the researchers just cited employed positive reinforcers, successful operant conditioning of autonomic responses is not restricted to this class of reinforcer. For example, several investigators have successfully used aversive reinforcers to operantly modify electrodermal responses by using an avoidance design (Edelman, 1968, 1970; Grings & Carlin, 1966; Kimmel & Baxter, 1964; Kimmel, Sternthal & Strub, 1966; Kimmel & Sternthall, 1967; Kimmel & Kimmel, 1968; Martin Dean & Shean, 1968) or a punishment design (Crider, Schwartz & Shapiro, 1968, 1970; Johnson & Schwartz, 1967; Senter & Hummel, 1965).

Moreover, successful demonstrations of operant conditioning of autonomic activity have not been restricted to the use of electrodermal responses. Operant techniques have also been employed to modify _heart rate_ (HR) (Ascough & Sipprelle, 1968; Brener & Hothersall, 1966, 1967; Engel & Hanson, 1966; Engle & Chism, 1967; Shearn, 1962) _vasomotor responding_ (VMR) (Snyder & Noble, 1966, 1968) _salivation_ (Brown & Katz, 1967), and _electrical activity_ of the brain (Bry, 1970; Kamiya, 1967, 1968, and Nowlis & Kamiya, 1970) all in human beings. Animal work has also shown modification of _heart rate_ (DiCara & Miller, 1968a, 1969a, 1969b; Malmo, 1963) _blood pressure_ (Plumlee, 1968, 1969) _salivation_ (Miller & Carmona, 1967), _evoked potentials_ (Fox & Ruddell, 1968, 1970), and the _firing of a single neuron_ in the precentral cortex (Fetz, 1969). Despite these apparently successful studies, evidence for operant conditioning of autonomic responses is not entirely clear. For example, some researchers have been unsuccessful in their attempt to operantly condition electrodermal activity in humans (Mandler, Preven & Kuhlman, 1962; Mednick, 1964; Stern, Boles & Dionis, 1966; Stern, 1967). Others have been unable to condition HR deceleration (Headrick, Feather & Wells, 1971; Levene, Engel & Pearson, 1968).

All these studies have concentrated on demonstrating the _existence_ of operant conditioning of autonomic activity. During a conditioning study, increases in the rate of responding could be due merely to the effect of the reinforcer as a stimulus rather than to its reinforcing effects. To control for this effect of sensitization to the reinforcer, designs with control groups have been used. There are, however, two prominent difficulties with the experimental designs used: Results may be biased by (1) reinforcing control subjects only during period of non-responding or (2) by using a yoked control group. The first group of studies in this area followed the experimental design of Kimmel and Hill (1960). Subjects in the experimental groups were reinforced for spontaneous autonomic activity while those in the control groups received reinforcement contingent on non-responding. They were reinforced only during period when they did not show spontaneous autonomic activity. This had the effect of biasing downward the number of responses seen in the control group; Ss could have been about to emit a response at the point the reinforcer was delivered. This reinforcer would mask the spontaneous response that might otherwise have been seen or is followed by a spontaneous response that is erroneously attributed to the reinforcer. Thus a difference seen between the experimental and control groups might be due to this bias and not to a conditioning effect. Some of the studies subject to this criticism include Fowler & Kimmel (1962), Kimmel & Kimmel (1963), Crider et al. (1966), Van Twyver and Kimmel (1966), Greene & Nielson (1966), and Schwartz & Johnson (1969). One way of overcoming this problem is to examine only extinction data where there are no reinforcers to mask possible responses. The studies by Kimmel & Hill (1960), Fowler & Kimmel (1962), Green & Nielson (1966), Gavalas (1967), and Defran, Badia & Lewis (1969), did find differences during extinction, but other studies (for example, Crider, Shapiro, & Tursky, 1966; Fowler & Kimmel, 1962) have not found such differences.

A second procedure for ascertaining that increases in response rate are not due merely to sensitization is to employ a yoked control group. Researchers using this control include Greene (1966), Stern (1967), Kimmel & Baxter (1964), Grings and Carlin (1966) and Kimmel et al. (1966). Church (1964) points out that this design is also biased in favor of the experimental group. Individuals vary as to the effectiveness of the reinforcer for enhancing responsivity. If the reinforcer is an effective elicitor for the experimental S, more and more responses will be elicited as the experiment proceeds. If the experimental S is paired with his yoked control for whom the reinforcer does not elicit responses, the yoked S can be expected to show few responses to even the larger number of reinforcements quite independent of any experimental manipulations. If, however, the reinforcer is an ineffective elicitor for the experimental S he will give few responses and the yoked S will receive few reinforcements. If the reinforcer is an effective elicitor for the yoked S, responses would have been elicited, but because of whom he is paired with, he does not receive enough reinforcement to get this effect. Therefore, less responses will show on the record of control Ss even without conditioning effects. To combat this problem, many experimenters have matched Ss on the basis of the number of responses during the initial period -- on the operant levels. Johnson (1963) confirmed the feasibility of this procedure by pointing out the positive correlation between GSR operant levels and responsivity to non-contingent stimulation. An even better alternative might be to use each S as his own control. In this way, reactivity to the reinforcer would be perfectly matched for comparing performance during contingent and non-contingent reinforcement.

The models of Black and DeToledo (1969) suggest two ways that skeletal mediation can be involved in autonomic activity. First in the case labeled _parallel connection_, some central change is manifested in both autonomic and somatic responding. For example in thinking of an uncomfortable experience a person might not only show changes in electrodermal activity and heart rate, but might also fidget in his chair. In the second case, that of _overt chaining_, a centrally initiated change in skeletal activity might percipitate a change in autonomic activity. For example, movement or changes in respiration can produce changes in electrodermal activity.

If the model that Black and DeToledo label _parallel connection_ is correct, the organism should show changes in addition to the change that is conditioned. For example a change in respiration or muscular activity might accompany a conditioned increase in the rate of the production of spontaneous GSRs. If it is the case that several changes accompany the change that the experimenter claims to have conditioned, then he cannot argue that the organism can directly control specific autonomic activity. The organism might instead be initiating some overall state of arousal which manifests itself in many ways. To control for the possibility that increased arousal could cause multiple responding, experimenters have shown that one response can be conditioned without effecting a second response. Kimmel and Kimmel (1967) measured GSR and vasomotor responding from two groups of _S_s while conditioning GSR in one group and VMR in the other. Reinforcing GSRs significantly increased the frequency of spontaneous GSRs and decreased the frequency of drops in blood volume. Reinforcing VMRs increased the frequency of VMR and GSR changes. They attribute this result to the inadvertant reinforcement of simultaneous events since many GSRs were initially accompanied by VMRs. In deeply curarized rats, Miller and Banuazizi (1968) showed a similar phenomena by separately conditioning intestinal contraction/relaxation and HR increase/decrease. Changes in HR were not found when intestinal contractions were conditioned, and the rate of intestinal contraction did not change when HR was conditioned. Another study indicating specificity of responding is that of DiCara and Miller (1968b) who successfully conditioned rats to show vasodilation in one ear and vasoconstriction in the other ear. There were no changes in VMR from other body locations. Snyder and Noble (1968) reinforced vasoconstriction and did not find any systematic change in respiration rate, respiration irregularity, forearm electromyographic recording (EMG) or HR during conditioning. In a human study, Shapiro, Tursky and Schwartz (1970) conditioned HR changes without finding accompanying changes in blood pressure. Engel and Gottlieb (1970) found the same thing with rhesus monkeys. When Plumlee (1969) conditioned blood pressure increases in monkeys, there was no change in resting pressure and even in extensively trained animals, no histological indication of hypertension. On the other hand, DiCara and Stone (1970) have found different levels of catecholamine in rats trained in HR increase and those trained in HR decrease. This indicates a change resulting from conditioning which _may_ imply mediation.

Many researchers have employed masking tasks to control for possible influences of cognitive activity on (1) general arousal and therefore general somatic and autonomic activity or (2) specific autonomic responding. Gavalas (1967) had her _S_s read nonsense syllables from cards for one part of her study; another group of Ss were asked to pronounce nonsense syllables spelled to them over an intercom. Ascough (1967) told his Ss to guess about changes in their skin temperature while he was actually interested in HR changes.

By contrast, three studies have suggested changes in general arousal level during conditioning indicated by changes in other autonomic responses. Changes in arousal level were indicated by Mandler, Preven and Kuhlman's (1962) study of GSR conditioning. They found that conductance levels rise in the control period and in the beginning of the reinforcement and the extinction periods. While conditioning HR Ascough (1967) found GSR changes which he said reflected arousal away from a balance. DiCara and Miller (1968c) recorded changes in core body temperature in rats conditioned to show vasodilation or vasoconstriction in the tail.

Other studies have used statistical techniques to control for changes in other activity that might have accompanied the change brought about in the response under question by conditioning. The argument here is that even though there may be changes in other activity, conditioning may still be shown when these effects are statistically removed. Ascough (1967, 1968) used an analysis of covariance to control for the effect of respiration during his HR conditioning study. In their conditioning of salivation in dogs, Miller and Carmona (1967) wanted to correlate the number of days of training with the amount of salivation. After partialling out the effects of breathing and HR they still found significant changes in salivation over time. VanTwyver and Kimmel (1966) eliminated all GSRs that occurred within 5 seconds of a forearm EMG or respiratory irregularity.

Differences between the experimental and control groups were still found.

The model of overt chaining proposed by Black and DeToledo suggests that some subtle somatic change might initiate a change in autonomic activity. In this case conditioning an autonomic response might only have the effect of changing somatic activity which in turn causes the change in autonomic activity. Kendon Smith (1954) contends that neither operant _nor_ classical conditioning of autonomic activity can _ever_ be proved to be independent of somatic mediation. For any experiment that claims to demonstrate control of autonomic activity, he can argue that there was an undetected change in somatic activity that mediated the autonomic change. As an example of this, Obrist et al. (1970) says that cardiac components are inextricably tied to somatic components. They report correlations between HR increase and EMGs from the chin, jaw, and mouth areas. Therefore to reinforce HR changes is to inadvertantly reinforce the subtle EMGs which can perhaps he said to "cause" the HR changes. Conditioning studies by Shean (1970) and Edelman (1970) traced the changes they found to mediators. Similarly Carroll (1970) found that motor behavior and respiration aided HR change.

Some researchers have designed experiments to specifically eliminate or control for certain somatic mediation. Brener and Hothersal (1967) trained their _S_s to breathe at a fixed rate and amplitude. With _S_s breathing in this way they demonstrated successful HR conditioning. The HR changes observed could not have been attributable to changes in respiration rate or amplitude. By using _S_s who were controlling their breathing, and reinforcing only GSRs occurring in the absence of forearm EMGs, Rice (1966) demonstrated conditioning of the GSR independent of these two possible sources of mediation. Schwartz and Johnson (1969) initiated a time out period during which no S received reinforcement if he coughed, sighed, took deep breaths, made gross movements, or there were outside noises, or abrupt increases or decreases in heart rate. In this way no GSR that was elicited in any of these detectable ways was reinforced.

One way to separate the effects of somatic and autonomic activity is to eliminate the possible confounding effects of somatic activity by the use of the drug curare which blocks virtually all muscle activity. Birk, Crider, Shapiro & Tursky (1966) demonstrated operant conditioning of skin potential (SP) in a single curarized human being. However, since curarization of a human is a complex procedure requiring the supervision of a skilled anesthesiologist, the technique is primarily limited to animal work. When curare is administered to animals to eliminate muscular activity and they are maintained on an artificial respiratory system, it becomes possible to demonstrate operant conditioning of autonomic activity independent of muscular or respiratory mediation. Curarization has been used particularly in studies modifying HR (Black, 1967a, 1967b; DiCara & Miller 1968a, 1969a; Hothersal & Brener, 1969; Hothersal, 1969; Miller & DiCara, 1967; Miller & Banuazizi, 1968; Trowill, 1967).

It is possible that curarized animals who cannot make any movement are sending signals to their muscles to move but that curare blocks the expression of these. It could be that these movement signals also cause a change in autonomic activity -- and that these are being conditioned rather than the autonomic activity's being directly conditioned.

To test this, DiCara and Miller (1969b) initially conditioned HR increases in curarized rats. Then they observed the animals in the same situation after the effects of curare had worn off. If central messages to move had accompanied the HR changes, movement could have been expected when the curare wore off. They observed some initial movement, but this tapered off. Miller (p. 442, 1969) reports DiCara's observation that rats recovering from curare "that had been trained, through the avoidance or escape reward, to increase their heart rate were more likely to squirm, squeal, deficate and show other responses indicating emotionally than were those that had been trained to reduce their heart rate." These indicate that some signals for somatic changes may have accompanied the conditioning and this suggests that conditioning of the autonomic activity might not have been direct. The studies with curarized animals have either used an avoidance design or they have relied on electrical stimulation of the brain as a positive reinforcer. Unfortunately such designs make it difficult to compare the animal work with human work using more common reinforcers.

There is, however, one very good animal study by DiCara and Miller (1968b) which argues against the necessity for somatic mediation in operant conditioning of autonomic activity. Using curarized and artificially respirated rats they conditioned vasodilation in one ear and vasoconstriction in the other. If the observed conditioning had been an artifact caused by a change in arousal level; vasomotor activity of the tail, body temperature and heart rate might have been expected to show changes -- but no changes were observed in these indicators. If the animal controlled the right and left sides of the body independently, in addition to the differences found in the ears, other differences in the two sides of the body might have been expected. However there was no change in either the right or left forepaw. This indicates extremely specific control of autonomic activity. In another study comparing responding in the right and left sides of the body, Wyatt and Tursky (1969) used human beings to show that somatic changes similarly effect both sides of the body. For example, when they delivered a shock to the left side of the body they did not find a larger skin potential response on that side than on the right side. They found similar responding on both the stimulated and unstimulated sides. However they found that most Ss consistantly gave somewhat larger responses in one hand, for Ss the right hand showed somewhat larger responses regardless of the side of the body stimulated by shock. Pilot work for the present study has indicated that somatic changes such as changes in respiration or movements produce similar changes in skin potential in both hands -- generally with a somewhat larger response in the right hand.

Thus the question of operant conditioning of autonomic activity has by no means been answered. Not only did early studies use biased designs, but they also failed to address the question of possible mediation. Studies that have tried to see if change in other activity accompanies the change in the conditioned response have had mixed results. Researchers statistically controlling for this can only control for the selected activity that they record. When experiments are designed to control for possible sources of somatic mediation, they have to limit their conclusions to those sources they controlled. Animal studies have eliminated somatic activity by curare but are open to criticism because differently conditioned animals show different activity as the curare wears off. The animals have not learned to directly control only specific autonomic activity. In addition, the animal studies use techniques that are not practical for applications to human beings.

Therefore the present study was designed to demonstrate operant conditioning of autonomic activity independent of somatic mediation. The present study follows a design similar to that of DiCara and Miller (1968b). It attempts to differentially condition electrodermal activity in the two hands; responses of a much larger magnitude in one hand than in the other hand were reinforced. Because responses elicited by somatic changes are of similar magnitude in both hands (Wyatt and Tursky, 1969), conditioning dissimilar responses in the two hands would demonstrate operant conditioning independent of somatic mediation. For this within S design, half the Ss received contingent reinforcement for their first sessions and non-contingent reinforcement for their later sessions; for the other half the order was reversed. In this way, S's performance during contingent reinforcement and non-contingent reinforcement could be compared. Because the operant level for responses of this type (much larger in one hand than the other) was very low, it was necessary to have several reinforcing sessions and to use a powerful reinforcer. Since recording GSR involves introducing a small current to the body and since introducing currents to both sides of the body simultaneously may interfere with the activity of the heart, the SP response was used to enable recording from both sides of the body without introducing a current.

METHOD

Subjects

Twenty-eight male undergraduate students, enrolled in introductory psychology courses at Michigan State University received extra course credit for their participation in the screening session experiment. Of these, 8 met the criteria and received a greater amount of extra credit for their longer participation in the study.

Apparatus

SP was recorded both AC and DC with Beckman biopotential electrodes placed at active site on S's thenar eminance and a referant site on the inside of S's arm 1 inch below the elbow. Attachments were made on the right and left sides of the body. A ground was placed about 5 inches below the left referant electrode. The AC record was used for determining criterion responses while the DC record served as a backup by recording all SP changes. Since movement artifacts are more clear on the DC record than on the AC record, this helped eliminate from the analysis all movement associated responding. The AC signal was recorded on two Grass Wide Band AC EEG Pre-amplifiers (7P5A) having time constants of .45 seconds and a sensitivity of 1 mv/cm. For DC recording, the signals from the same electrodes were also fed into two Grass low-level DC Pre-amplifiers (7P1A). For reinforcement, slides of female nudes were shown to male Ss. This is the same reinforcement that Schwartz and Johnson (1969) used to successfully condition GSR.

This reinforcer has also been successfully used by Lovibond (1963) and DeFran, Radin and Lewis (1969).] The reinforcing stimuli were 55 chromatic slides of the female nudes taken from a popular magazine. The 10 in. x 10 in. image was shown by rear projection on a 2 ft. x 2 ft. ground glass screen placed 3 feet in front of *S*. The three-second duration of the slides was controlled manually by advancing the projector to a black slide which projected no image.

Design and Procedure

The first session for all *S*s was a screening session used to obtain operant levels for responding and to obtain a record of elicited responses. These sessions took place during the two weeks prior to the beginning of the experiment. Responding during these sessions was used as a basis for selecting *S*s for participation in the main experiment. The eight *S*s that were selected were then randomly assigned to Group I or Group II. The two groups differed in the order of the contingent and non-contingent reinforcement sessions. Table 1 indicates the sequence of the sessions.

Insert Table 1 about here

Group I had the following sequence: (a) four contingent reinforcement sessions (C), (b) one extinction session (E), (c) four non-contingent reinforcement sessions (NC), and (d) one E session. The sequence for Group II was: (a) four NC sessions, (b) one E session, (c) four C sessions, and (d) one E session. Pilot work indicated little change in performance over subsequent extinction sessions.

Table 1

Sequence and Number of Sessions

for Group I and Group II

	Week One		Week Two	
	Number of Reinforcement Sessions	Number of Extinction Sessions	Number of Reinforcement Sessions	Number of Extinction Sessions
Experimental Group I	4 Contingent	1	4 Non-contingent	1
Experimental Group II	4 Non-contingent	1	4 Contingent	1

Subjects were seated in a dimly lighted sound attenuated room with an ambiant noise level of 51 db. and a temperature of approximately 70°F. An intercom allowed communication between the experimental room and the adjacent recording room. Before attaching the electrodes and proceeding with the screening session, an explanation of the experiment was given to S and his permission was obtained. (See Appendix A). Subjects were instructed to remain alert and to refrain from moving during the experiment. Only a male experimenter had contact with S until after the last session. After two minutes for machine adjustment, the beginning of the experiment was announced over the intercom and approximately fifteen minutes of baseline recording was made. Elicited responses were then obtained by delivering one reinforcement and asking S over the intercom to do a series of things: hold his breath; move his feet; make a fist with the right then the left hand; move his head back and forth; breathe in and out rapidly; think emotional thoughts; relax as completely as possible; and to tense his whole body. E waited until S had ceased responding to each stimulus before requesting the next action.

The recording from the AC channel was used to determine the number of criterion responses. The criterion was production of a negative wave SP in one hand three or more times as large as the negative wave SP in the other hand (this is a 1:3 ratio). A large ratio would be most desirable because it would be most likely to be detectable by S. However, if too large a ratio was chosen, almost no Ss would have a sufficient number of criterion responses for conditioning to be possible. The ratio was chosen on the basis of the pilot work. It was the largest ratio such that more than a third of those Ss screened had a sufficiently high operant level. In addition, the larger responses had to be of a magnitude of .3 mv. or greater.[1] Very small responses may not be mediated centrally (VanTwyver & Kimmel, 1966) and thus may not be amenable to operant modification. Using only the negative wave component of SP makes the criterion definition consistent for all Ss and only eliminates a very small number of monophasic positive responses. Only Ss showing seven criterion responses with the larger response in the same hand during the fifteen minutes of baseline recording were continued in the study. This was done because some studies have indicated that at least thirty reinforcements are necessary for this type of conditioning (Milstead, Baer & Fuhrer, 1968; Crider, et al., 1966). If S continued to give at least seven criterion responses for each of the four conditioning sessions, he would receive close to thirty reinforcers. Subjects whose elicited responses consistently met the criteria were eliminated since criterion responses could not be considered as independent of somatic mediation in that case.

Subjects selected in this way had five afternoon sessions a week for two weeks. Each S was instructed only that the recordings would be made during the baseline session and that he should see what he could do to view as many slides as possible. Non-informative instructions were selected because Engle and Hanson (1966) found that all four Ss who correctly inferred that HR changes were being reinforced were among the five non-learners. In addition, for a somatic response, Hefferline (1962) found poorer performance among Ss without such

---

[1] Because of the filers used (3½ amp hi freq on the driver amplifier and .15½ amp lo freq on the AC preamplifier) responses are somewhat attenuated. Therefore a response recorded as .3 mv. is actually somewhat larger. Since the attenuation is constant, the criterion magnitude is consistent although not exactly .3 mv.

instructions. Greene and Nielson (1966) found that Ss who scored high on Mandler's Autonomic Perceptibility Questionnaire showed less increase in GSRs than Ss with less autonomic awareness.

Each session consisted of twenty minutes of recording, then S was asked how he thought he did, and what ideas he had about how he might be controlling the slides. During the contingent reinforcement sessions, reinforcement was delivered when it was the consensus of the two experimenters that a criterion response had occurred. When a criterion response occurred a slide was shown for three seconds, then there was a ten second blackout period. Since responses during this blackout period were probably elicited by the reinforcement, they were not reinforced even if they met the criterion. Blackout periods of this length were used by Crider, et al. (1966). During the extinction sessions, no reinforcement was delivered. During the non-contingent reinforcement sessions, reinforcements were delivered at random intervals and followed by the same blackout. The total number of non-contingent reinforcers delivered for each session was approximately one and one half times the number of criterion responses that occurred during the initial baseline session. This meant that more reinforcers were delivered during the non-contingent sessions than during the contingent sessions. This should give an upward bias to the number of criterion responses during the NC period and provide a conservative measure with which to compare the C periods.

Data Reduction and Analysis

To reduce the eighty experimental records to manageable form, the magnitude of all responses were determined. Only responses that met the criteria were considered in the total number of responses.

Responses that were associated with sound from the experimental chamber that might have indicated movement or some bodily change such as a cough were eliminated since these were clearly elicited by something beyond the experimenter's control. Responses where neither recording channel indicated a change of .3 mv. or more were not included in the total because these small responses may not be detectable to S. Positive wave SP responses were also eliminated because these may be controlled by a different mechanism than negative wave SPs. As an exception, responses that had a positive component less than the .3 mv. detectable level were included as long as the responses on the other side of the body was negative going and at least .3 mv. The responses to the "begin" and "end" announcements were not included in the total group of responses.

Responses included in the total that also met the criterion of being three or more times as large in the designated hand as in the other hand and of being of minimum magnitude (.3 mv.) in at least one hand were called criterion responses. All responses were classified as either spontaneous or elicited. Elicited responses were defined as all responses occurring within thirteen seconds of the onset of the reinforcer or within thirteen seconds of the peak on the AC channel of a criterion response. This thirteen seconds included the three seconds during which the slide was exposed and the ten second blackout period. Those responses that were not elicited in either of the above ways were called spontaneous. These spontaneous responses were therefore not elicited in any way detectable to the experimenter. To look at the relationship between the number of spontaneous responses and total responding, a ratio was made of the number of spontaneous criterion responses divided by the total number of spontaneous responses. This gives the proportion of the spontaneous responses that met the criterion.

An analysis of variance was used to determine the effects of the experiment on these variables. In each of these analyses, some of these four factors were used: (1) Group -- was *S* in Group I or Group II. (2) Contingency -- during that week was *S* receiving contingent or non-contingent reinforcement. (3) Sessions -- this refers to the session of the week regardless of the contingency of reinforcement. (4) Time -- this refers to the time periods within the sessions. To see if there might have been some effects within the contingent sessions or within the non-contingent sessions, simple effects were tested. This analysis served to indicate if there were significant differences within the contingent sessions considered by themselves and within the non-contingent sessions by themselves.

All eight *S*s completed their ten experimental sessions. For one *S* scheduling difficulty arose which necessitated running two sessions in one day -- one in the morning and one in the afternoon. All others had one session at the same time each weekday for two weeks. On three separate occasions the slide projector failed to operate correctly and the reinforcing slides were exposed for much longer than three seconds. Since these sessions cannot be appropriately included in the analysis, means from the other *S*s in that condition on that day were used as data points for these *S*s in the analysis.

RESULTS

Screening Session - Baseline Recording

Twenty-eight Ss had screening sessions before eight were selected who had sufficiently high operant levels. One additional S had a sufficiently high operant level, but was unable to find time to participate in the study. One of the selected Ss showed only six criterion responses during twenty-two minutes of baseline recording. He was included because such a high proportion of his small number of total responses met the criterion. For the two Ss whose baseline recording periods were only 10 minutes long, the number of responses that might have occurred during the next 5 minutes was assigned to the third 5 minute block of time. This method of estimating was chosen since there did not seem to be consistent increases or decreases over time for the other Ss. The same method of adjustment was used to estimate the number of responses that would have occurred if their first contingent reinforcement session had continued for 20 minutes instead of 10. So that performance during the 15 minute screening sessions and the 20 minute experimental sessions could be compared, an estimate was made of the number of responses that might have occurred if the screening session had extended 5 additional minutes. The number of responses during the first 15 minutes was multiplied by 4/3 to obtain this estimate.

For the eight Ss that were selected, performance during the screening sessions was used to determine which hand showed larger responses during criterion responding. Four of the Ss showed larger responses in the right hand, 4 showed larger ones in the left hand. The number of criterion responses during the fifteen minutes varied from 3 to 31 with a mean of 18.75 (SD = 10.138). For two Group I subjects, no criterion responses in the criterion direction were emitted during the first ten minutes of their first contingent session, while a large number of criterion responses in the opposite direction were emitted. For this reason, the criterion direction was changed for one subject from right to left and for another from left to right at that point. For these two subjects, the number of criterion responses during the first ten minutes of their C session was used for baseline data.

The number of AC responses made by each S during the screening session can be seen in Table 2. The total number of responses and the criterion responses are separately divided into elicited and spontaneous responses. The number of positive going responses varied from none to 14 -- these responses are indicated in Table 2 but have not been included in the total number of responses. Table 3 gives the estimated number of responses if the screening session had continued for 20 minutes. These estimated numbers can be compared directly to the data from the twenty minute experimental sessions.

Insert Table 2 about here

Table 2

Number of AC Responses During Fifteen Minutes of Screening Session

Subject	Number Criterion Responses	Number Total Responses	Number Positive Responses	Number Criterion		Number Total	
				Elic.	Spon.	Elic.	Spon.
1	11	94	0	3	8	11	83
2	3	27	4	0	3	0	27
3	26	62	14	7	19	13	50
4	10	28	1	1	9	1	27
5	31	80	2	9	22	23	57
6	18	74	0	3	15	16	58
7*	30	73	6	0	30	21	52
8*	21	50	1	8	13	12	38
Total	150	488	28	31	119	97	392
Mean	18.75	61	3.5	3.8	14.8	12.1	49

*Tabled data estimated by taking 3/2 of the number of responses occurring during the ten minutes of baseline recording.

Insert Table 3 about here

Screening Session - Elicited Responses

The initial AC responses elicited by asking S to perform certain actions can be seen in Table 4. These initial elicited responses can be compared with (1) the first 5 responses elicited by each stimulus (2) the data from the 15 minutes of baseline recording (3) the responses during all 8 experimental sessions. In this way it is possible to see if the elicited responses differ from those not elicited. Elicited responses were more often positive going than non-elicited responses. 36.04% of the initial elicited responses and 28.50% of the first 5 responses elicited by each stimuli were positive going while only 5.42% of the responses in the 15 minutes of baseline recording and 6.75% of the responses from the 8 experimental sessions were positive going. This indicates a difference in the typology of the responding for elicited and non-elicited responses. These comparisons can be seen in Table 5. The percentage of criterion responses occurring in these conditions is also presented in Table 5. A smaller percentage of the elicited responses meet the criterion than do the non-elicited responses. This is especially true of the initial elicited responses where only 1.16% of the total responses were criterion responses. By contrast, 13.9% of the total responses

Insert Table 4 about here

Table 3

Estimated Number of AC Responses if Screening Sessions had Continued for Twenty Minutes*

Subject	Number Criterion Responses	Number Total Responses	Number Positive Responses	Number Criterion		Number Total	
				Elic.	Spon.	Elic.	Spon.
1	15	126	0	4	11	15	111
2	4	36	5	0	4	0	36
3	35	84	19	10	25	17	67
4	13	37	1	1	12	1	36
5	41	107	3	12	29	31	76
6	24	98	0	4	20	21	77
7	40	97	8	0	40	28	69
8	28	67	1	11	17	16	51
Total	200	651	37	41	158	129	523
Mean	25	81.4	4.6	5.1	19.7	16.1	65.4

*Tabled data estimated by taking 4/3 of the number of responses occurring during the fifteen minute screening session.

Table 4

Magnitude of Initial Elicited Responses on the Right and Left AC Channels in mv.

Subject	1		2		3		4		5		6		7		8	
hand	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
slide	-2.5+	-3.3+	-2.0	-2.8	-2.8	-3.5	-1.0	-1.1	-1.4	-2.3	-2.2	-2.3			+3.0	+1.8
hold breath	-1.2	-1.0	- .8	-2.0	-1.0	-1.6	- .6	- .4	- .8	-2.1	-1.3	-1.7	-3.0	-1.5	+2.1	+1.8
breath out	-1.2	-1.5	+7.2	+6.8	+2.4	+5.0	- .3	- .4	+2.8	+2.5	- .8	-1.5	+ .6	-3.6	-4.2	-5.1
move feet	-1.8	-7.5	+4.8	+4.4	un	+3.6	- .6	+ .5	+2.8	-3.2	- .6	-1.3	-6.0	+8.1	-7.5	-9.0
right fist	+2.1	+3.3	+5.2	-5.2	- .8	- .8	+2.2	+ .6	+6.0	+4.2	- .3	- .8	+6.3	+6.3	-2.1	-1.2
left fist		+4.2	+9.2	+5.6	+1.6	+3.8	-1.0	- .9	+4.5	+3.9	- .1	- .4	+7.2	+6.6	-8.1	-10.5
move head			+2.0	+3.6	- .8	- .8	- .7	- .5	- .3	+2.1		- .3	+3.6	+4.2	-3.3	-5.1
breathe rapidly	+1.5	+2.4	- .4	-1.2	- .8	- .6	- .4	- .2	+4.5	+4.2			+5.1	+3.9	-1.8	-2.1
think emotional	- .1	- .9			+ .3	+1.0			+3.0	+3.3			+7.5	+6.0	-5.4	-7.5
relax body					un	- .9	- .7	- .6					+7.8	-5.1	-2.1	-2.4
tense body	+3.3	+2.7	- .4	-1.2	- .5	-1.2	+1.7	+2.5	+1.8	+2.1			+9.3	+5.7	-5.4	-6.3

were criterion responses in the experimental sessions. Table 5 also shows that a higher percentage of elicited responses were of greater magnitude than were non-elicited responses. Large responses were defined as those that were 2.5 mv. or larger or at least one hand. Thus the typical elicited responses was positive going, larger, and less likely to meet the criterion than were other responses.

Insert Table 5 about here

Reinforcement

To bias conservatively the number of reinforcements delivered during non-contingent reinforcement, a number of reinforcements approximately one and one-half times the number of criterion responses that occurred during the 15 minutes of baseline recording were delivered for each non-contingent reinforcement session. In this way, more reinforcers (mean = 24.06, SD = 12.36) were delivered during non-contingent reinforcement sessions than during most contingent reinforcement sessions (mean = 8.22, SD = 8.17). Therefore results seen are unlikely to be due merely to sensitization to the reinforcer.

For contingent reinforcement, two experimenters watched the record and determined visually if each response was of criterion magnitude and if a sufficient time had elapsed since the previous reinforcement so that the response could be considered spontaneous. When there was consensus between the experimenters, reinforcement was delivered manually. The number of contingent reinforcements delivered per session varied from 0 to 24 with a mean of 8.22 (SD = 8.17).

Table 5

Percentage of AC Responses that were Positive Going on Both Channels, of Criterion Magnitude in the Criterion Direction, and Greater than 2.5 mv. on the AC Channel.*

Percent of Responses in:	Initial Elicited Responses	First Five Responses Elicited By Each Stimuli	Fifteen Min. Baseline Recording From Screening Sess.	All Eight Experimental Sessions
That Were Positive Going	36.04	28.5	5.42	6.75
Of Criterion Magnitude in the Criterion Direction	1.16	7.45	29.06	13.90
Greater than 2.5 mv. on at least One Hand (AC) and Negative Going	12.79	17.10	2.32	5.67

* Only for the calculation of these percentages were positive going responses included in the total number of responses.

Because of the instantaneous nature of the judgment about whether or not a response met the criterion, there were errors in reinforcement. Most of these consisted of reinforcing a response which was slightly under the criterion level or of failing to reinforce a response slightly over the criterion level. Over all the contingent reinforcement sessions, 43 responses were reinforced that were not criterion responses, and 70 spontaneous criterion responses that should have been reinforced were not. A total of 199 reinforcements were correctly delivered. The total number of correct contingent reinforcers that each *S* received varied from 5 to 56 with a mean of 24.87 (*SD* = 16.72).

Criterion Responses

If conditioning had occurred, more criterion responses should have been seen during contingent reinforcement than during non-contingent reinforcement. Since only spontaneous criterion responses were reinforced, primarily the number of *spontaneous* responses was expected to increase. Table 6 contains the analysis of variance for the number of spontaneous criterion responses occurring during the ten sessions. It can be seen that there is a significant group effect.

Insert Table 6 about here

Subjects who had the contingent sessions first (Group I) had a lower level of criterion responses during their sessions than *S*s who began with non-contingent reinforcement. During their first two contingent sessions they had more criterion responses than during their first

Table 6

Analysis of Variance for the Number of Spontaneous Criterion Responses Occurring During the Ten Sessions

	SS	df	MS	F
Contingency	68.45	1	68.45	1.11
Group	414.05	1	414.05	6.72 *
Sessions	199.17	4	49.79	--
Contingency X Group	115.20	1	115.20	1.87
Contingency X Sessions	267.98	4	66.99	1.08
Group X Sessions	110.82	4	27.70	--
Cont. X Group X Sessions	159.13	4	39.78	--
Within cell	3699.22	60	61.65	--
Total	5034.02	79	--	--

*Significant at .05 level

two non-contingent reinforcement sessions. Performance during the 3rd and 4th acquisition sessions and the extinction session was similar regardless of the contingency/non-contingency for this group. Subjects who began the experiment with their non-contingent reinforcement sessions (Group II) showed a higher level of criterion responses during their sessions than the Ss in Group I. For the Group II Ss, there were a larger number of criterion responses in their first contingent session than in the first non-contingent session. But the third session contained more criterion responses under non-contingent reinforcement than under contingent reinforcement. Contingent and non-contingent reinforcement produced similar results in the other sessions. These effects can be seen in Figure 1. Although Ss were randomly assigned to Group I and Group II, there was a significant difference between the number of spontaneous criterion responses for the groups during the screening session. This initial difference explains the difference between groups that was seen during the experimental sessions.

Insert Figure 1 about here

Combining group one and two Ss to look at the effect of contingency gives a slight interaction. During contingent reinforcement the number of criterion responses decreases fairly steadily across sessions. The test for linear trend here was almost significant ($F_{(1,60)} = 3.23$, $P < .10$). During non-contingent reinforcement the number of criterion responses starts much lower, but rises above the

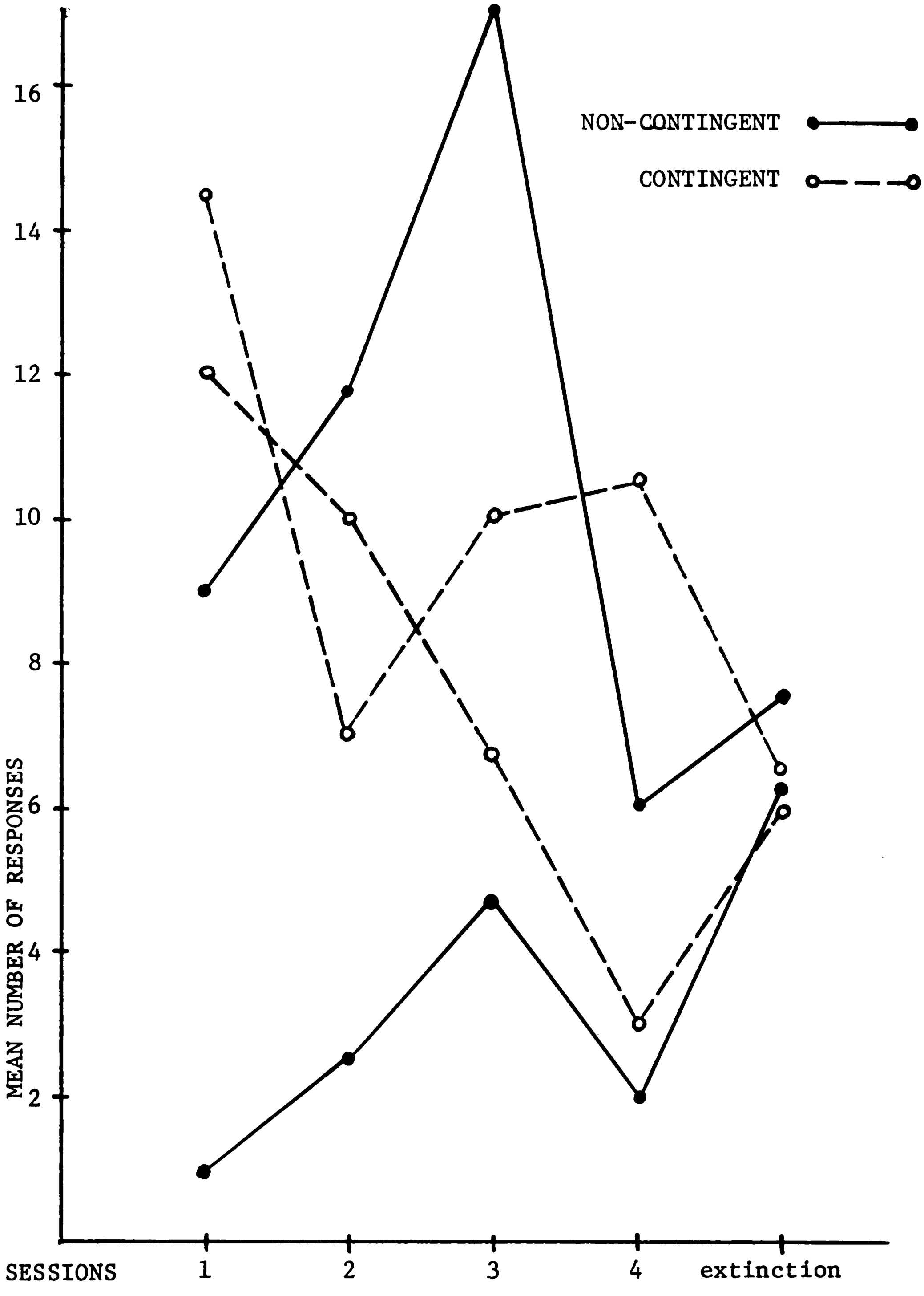

Figure 1. The mean number of spontaneous criterion responses by group I and group II Ss during contingent and non-contingent reinforcement sessions.

number that there were during the third contingent reinforcement session. The number then drops back. This can be seen in Figure 2.

Insert Figure 2 about here

During conditioning, it would have been expected that the number of spontaneous criterion responses would increase. The decrease that was seen may indicate a decrease in S's arousal or total responding -- this will be discussed later. Findings for the total number of criterion responses (including those elicited) were similar. The differences between groups was also significant ($F_{(1,60)} = 6.78$, $p < .05$). An analysis of variance for simple effects of sessions ($p > .05$), and Newman Keul's analysis did not indicate any significant effects ($p > .05$).

Total Number of AC Responses

An increase in the total number of responses may accompany the increase in criterion responses seen as a result of conditioning. This would indicate less specificity of control than if the total number of responses were not affected. First, the total number of responses (elicited and spontaneous, criterion and not) will be examined. Group II Ss gave a number of responses during their first 3 non-contingent sessions far larger than they gave in their first 3 contingent sessions or Group I gave in their contingent or non-contingent sessions. This indicates that the highest level of responding was obtained during the first week by subjects who received non-contingent reinforcement then. This shows up as a slight

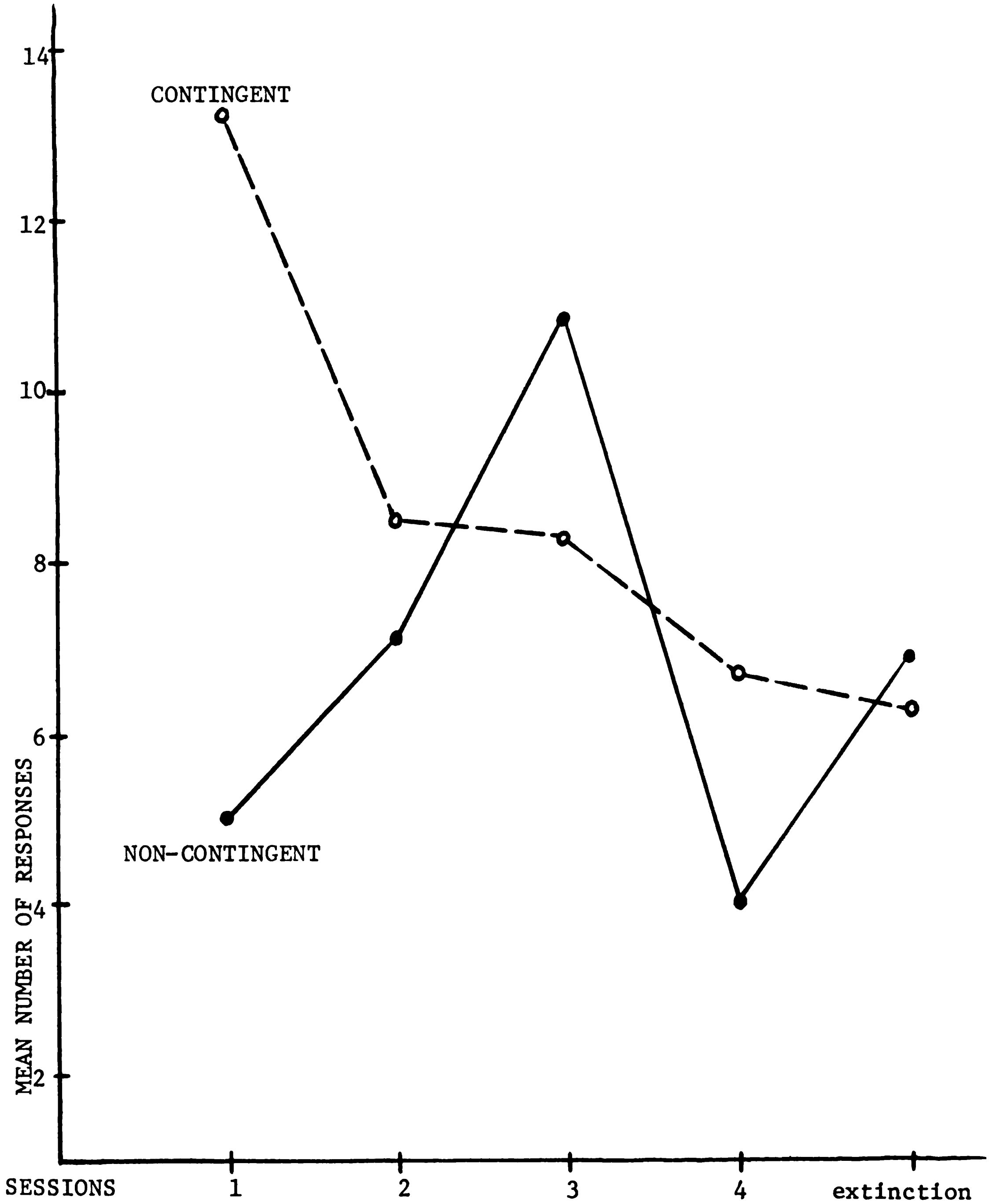

Figure 2. The mean number of spontaneous criterion responses during contingent and non-contingent reinforcement sessions.

interaction between contingency of the reinforcer and group of the subject ($F_{(1,60)} = 3.14$, $p < .10$). It may be that the larger number of reinforcers delivered there kept responding at a higher level which constrasted with the lower levels of the second week and of the contingent reinforcement. It cannot be explained as a S effect since groups did not differ during screening. This relation can be seen in Figure 3. When the extinction sessions were excluded from the analysis there was a non-significant trend for the contingency of reinforcement ($F_{(1,48)} = 3.65$, $p < .10$). More responses were given during non-contingent reinforcement than during contingent reinforcement for the conditioning sessions. This is probably attributable to the increased stimulation of more slides.

Insert Figure 3 about here

Analysis of simple effects for contingency of reinforcement did not yield significant results although both F values were greater than one. For contingent reinforcement this reflects the increase in responding seen during extinction; for non-contingent reinforcement this is primarily a result of decreased responding during extinction. Newman Keuls analysis did not indicate any significant differences between individual sessions.

To examine the effect of the increased number of reinforcers delivered, the number of elicited responses were examined. There were significantly more elicited responses during non-contingent reinforcement than during contingent reinforcement ($F_{(1,48)} = 28.23$, $p < .01$).

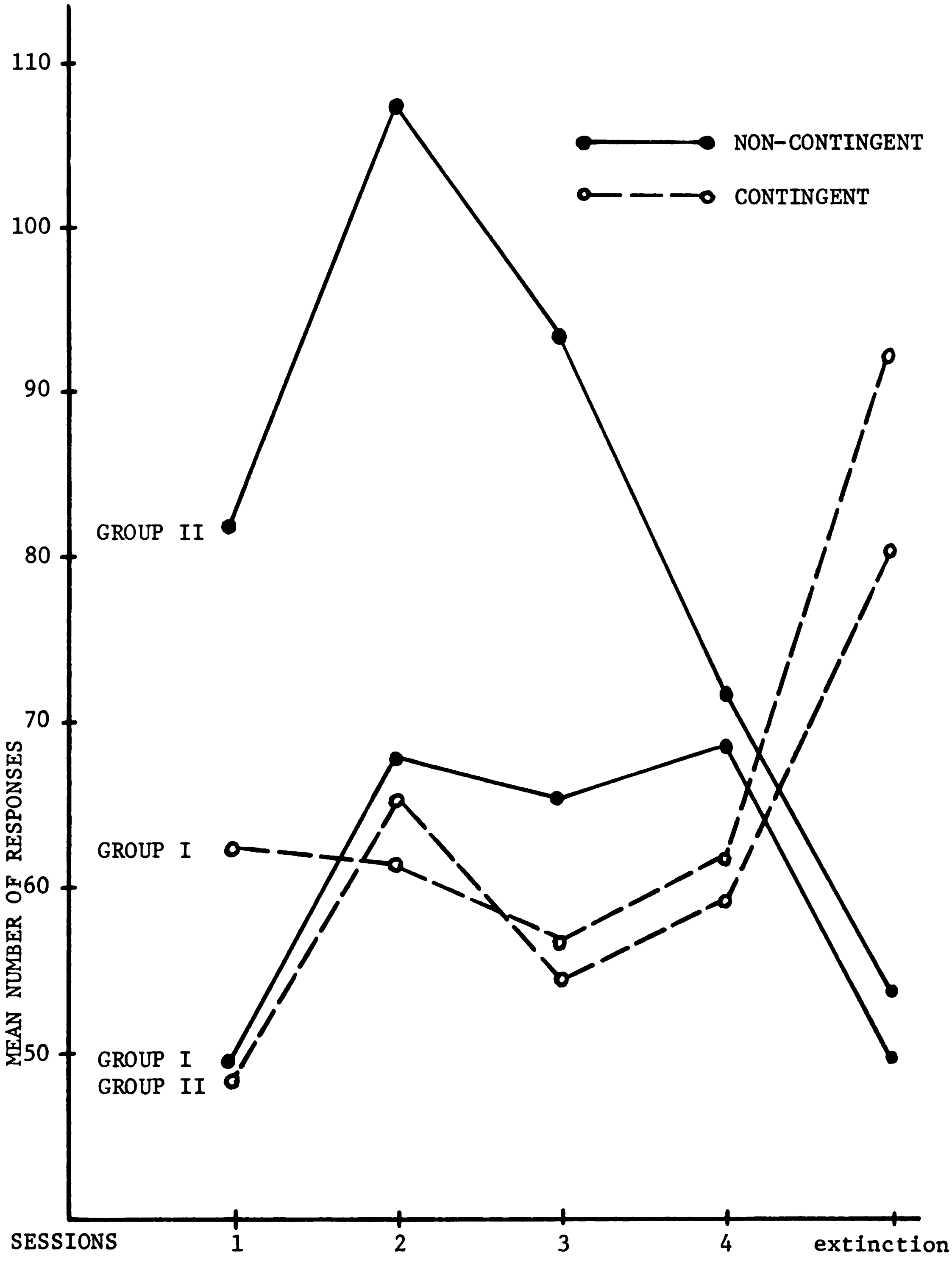

Figure 3. The mean total number of AC responses by group I and group II Ss during contingent and non-contingent reinforcement sessions.

This effect stands to reason because there were more reinforcers delivered which could potentially elicit responses during non-contingent reinforcement. There was also a small but not significant interaction between this contingency of reinforcement and S's group ($F_{(1,48)} = 3.70$, $p\ \ .10$). The interaction can be seen in Figure 4.

Insert Figure 4 about here

Since there were no reinforcers delivered during extinction, responses called elicited only include those occurring within thirteen seconds of a criterion response. For this reason, far fewer elicited responses were seen during extinction. When the analysis of variance is performed on all sessions -- including extinction sessions -- there is a significant sessions effect ($F_{(4,60)} = 3.90$, $p < .01$) which indicates that far fewer elicited responses were seen during extinction. A Newman Keuls analysis showed this significant difference between the extinction session and each of the contingent reinforcement sessions ($p\ \ .05$). There is also a significant interaction between the contingency of the reinforcer and sessions ($F_{(4,60)} = 3.72$, $p\ \ .05$) which is primarily contributed to by the difference during extinction. These effects can be seen in Figure 5. Within the non-contingent week, the simple effect for sessions was significant ($F_{(4,60)} = 6.84$, $p\ \ .01$). This reflects the rise to the middle sessions and the drop for extinction. The simple effect for sessions was not significant within

Insert Figure 5 about here

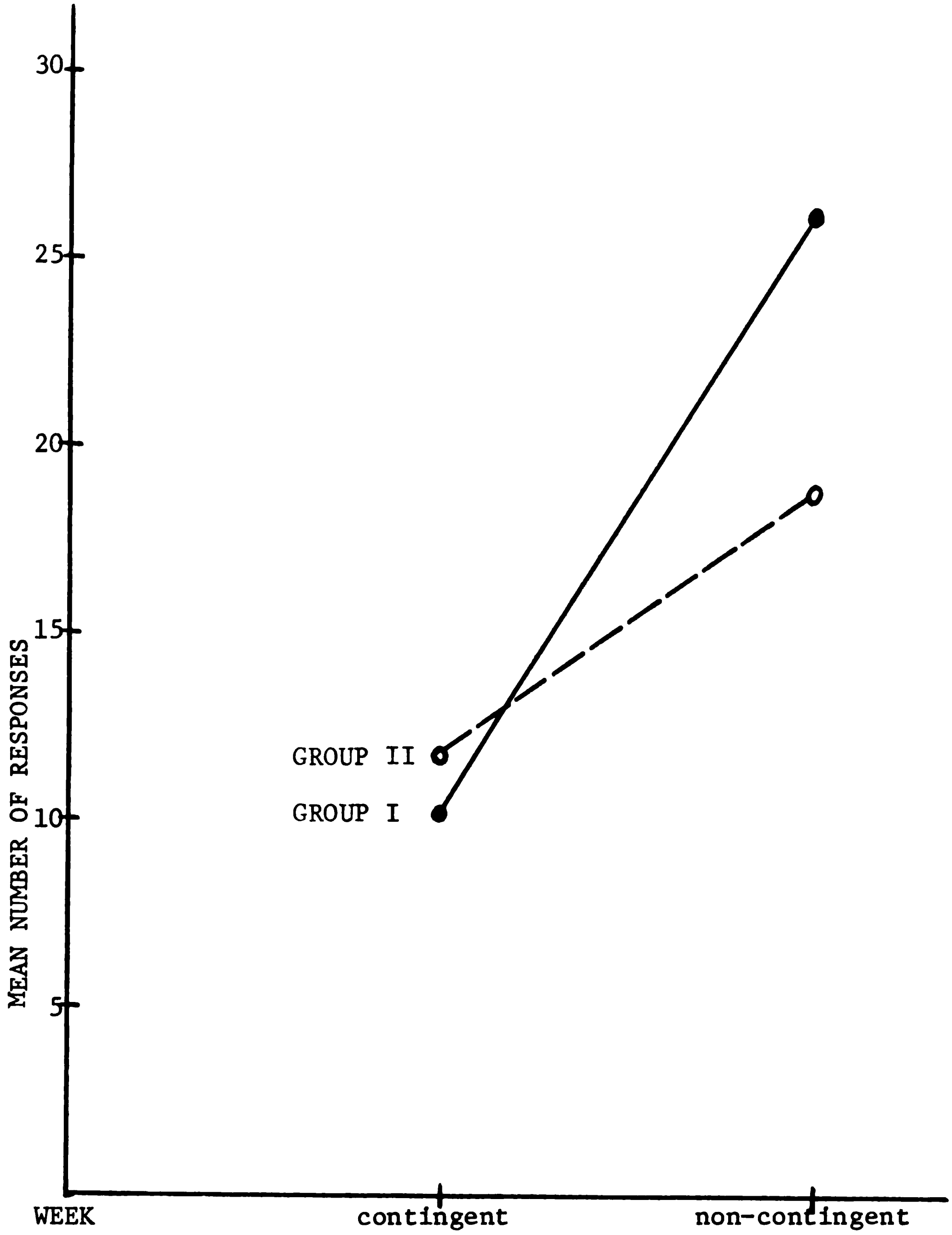

Figure 4. The mean number of elicited AC responses made by group I and group II _S_s during contingent and non-contingent reinforcement.

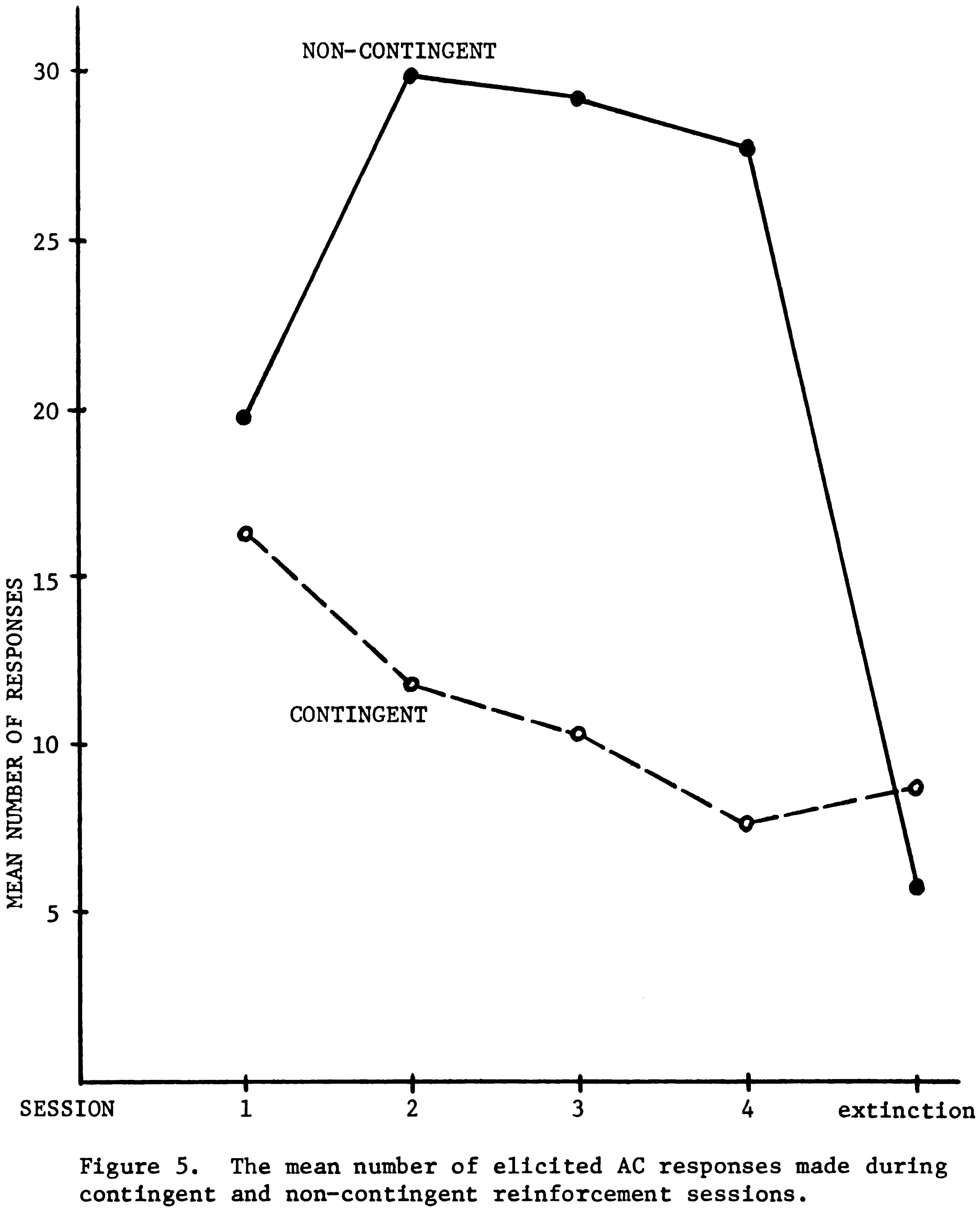

Figure 5. The mean number of elicited AC responses made during contingent and non-contingent reinforcement sessions.

the contingent week.

If the elicited responses are eliminated from the total number of responses so that only spontaneous responses are examined, differences independent of differences in the number of reinforcers can be examined. The analysis of variance for this can be seen in Table 7. There were not significant differences for the contingency of the reinforcer, group of S̲ or session of the week. However, there was a significant interaction between the contingency of the reinforcer and the group of the subject ($F_{(1,60)} = 9.98$, $p < .01$). The highest number of spontaneous responses occurred during the first week for Group I, the lowest for the second week for Group II. Even though responses elicited by the reinforcer have been eliminated, the presence of the larger number of reinforcers during the first week for Group I may have increased their arousal level and so their total responding. Both groups show similar declines from the first week to the second as can be seen in Figure 7 which is a redrawing of Figure 6 to show this decline.

Insert Table 7 about here

For the total number of spontaneous responses, there was an almost significant simple effect for sessions within the contingent week ($F_{(4,60)} = 2.24$, $p < .10$). This reflects the rise to the middle sessions and the further rise during extinction. The test for linear trend for this increase was significant ($F_{(1,60)} = 6.53$, $p < .05$). Additionally, the Newman Keuls analysis indicated that the first session of the contingent week was significantly different from the last

Table 7

Analysis of Variance for the Total Number of Spontaneous Responses Occurring During the Ten Sessions

	SS	df	MS	F
Contingency	536	1	536	--
Group	2680	1	2680	3.36
Sessions	3875	4	969	1.21
Contingency X Group	7969	1	7969	9.98**
Contingency X Sessions	4707	4	1177	1.47
Group X Sessions	3036	4	759	--
Cont. X Group X Sessions	233	4	58	--
Within cell	47894	60	798	--
Total	70464	79	--	--

**Significant at .01 level

extinction session ($p < .05$).

Insert Figures 6 and 7 about here

Ratio

Changes in the ratio of the number of spontaneous criterion responses to the total number of spontaneous responses indicated changes in the proportion of criterion responses. For Group I Ss the ratio was higher for each contingent reinforcement session than for the corresponding non-contingent session. Performances during the two extinction sessions were similar to one another. For Group II Ss the ratio was higher under contingent reinforcement than under non-contingent reinforcement for the first, third and fourth sessions. During all the reinforcement sessions contingent reinforcement produced higher ratios than non-contingent reinforcement during the comparable session. Reversal of this pattern was seen, however, during extinction. The effect for contingency did not reach significance ($F_{(1,60)} = 2.47$, $p < .25$) -- it can be seen diagrammed in Figure 8. During the third and fourth conditioning sessions Ss in Group II showed far higher ratios than those in Group I. This contributed to a nearly significant group effect ($F_{(1,60)} = 3.86$, $p < .10$). The ratios of the two groups across sessions can be seen in Figure 9.

Insert Figure 8 about here

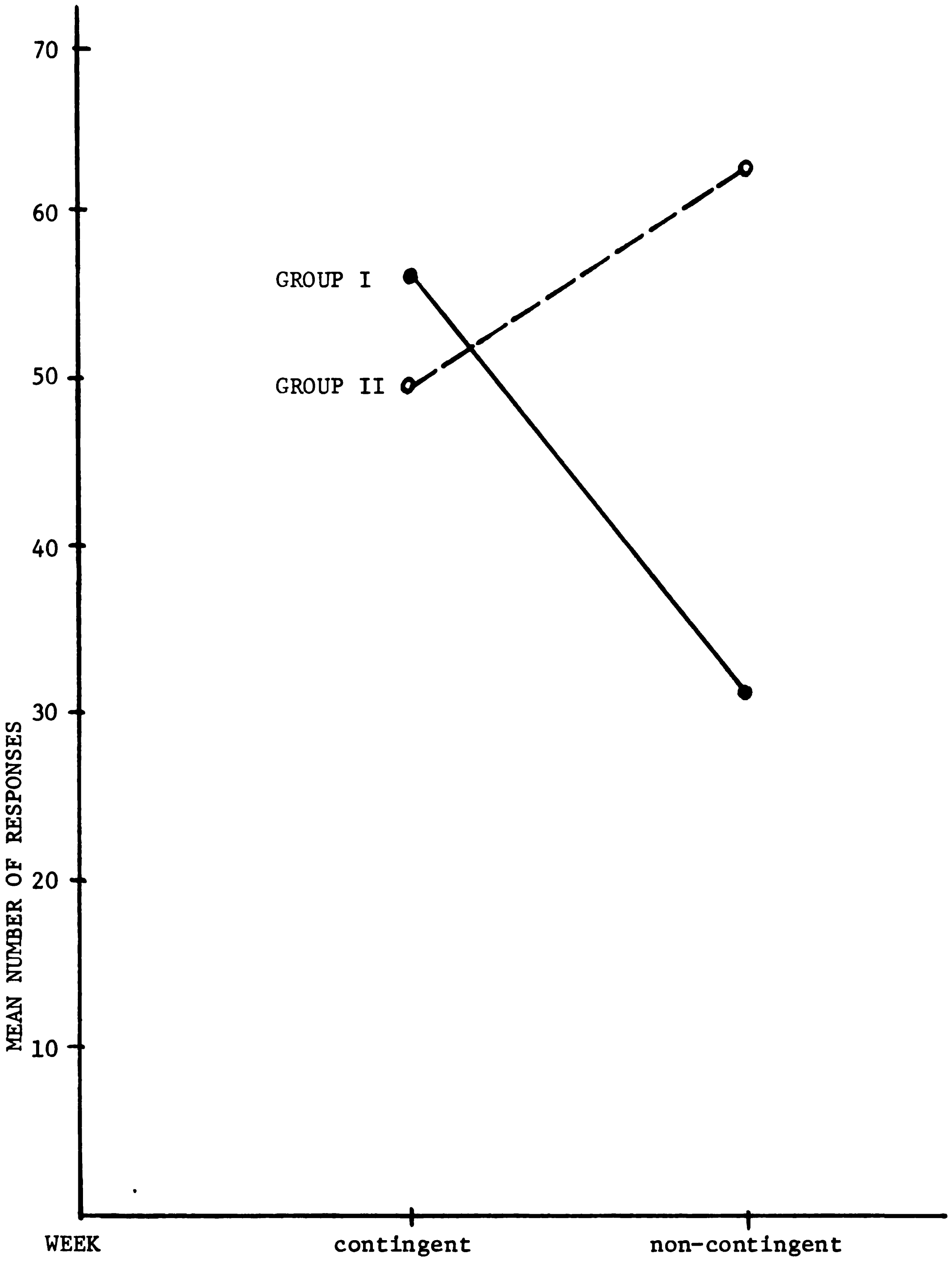

Figure 6. The mean number of spontaneous AC responses made by group I and group II Ss during contingent and non-contingent reinforcement.

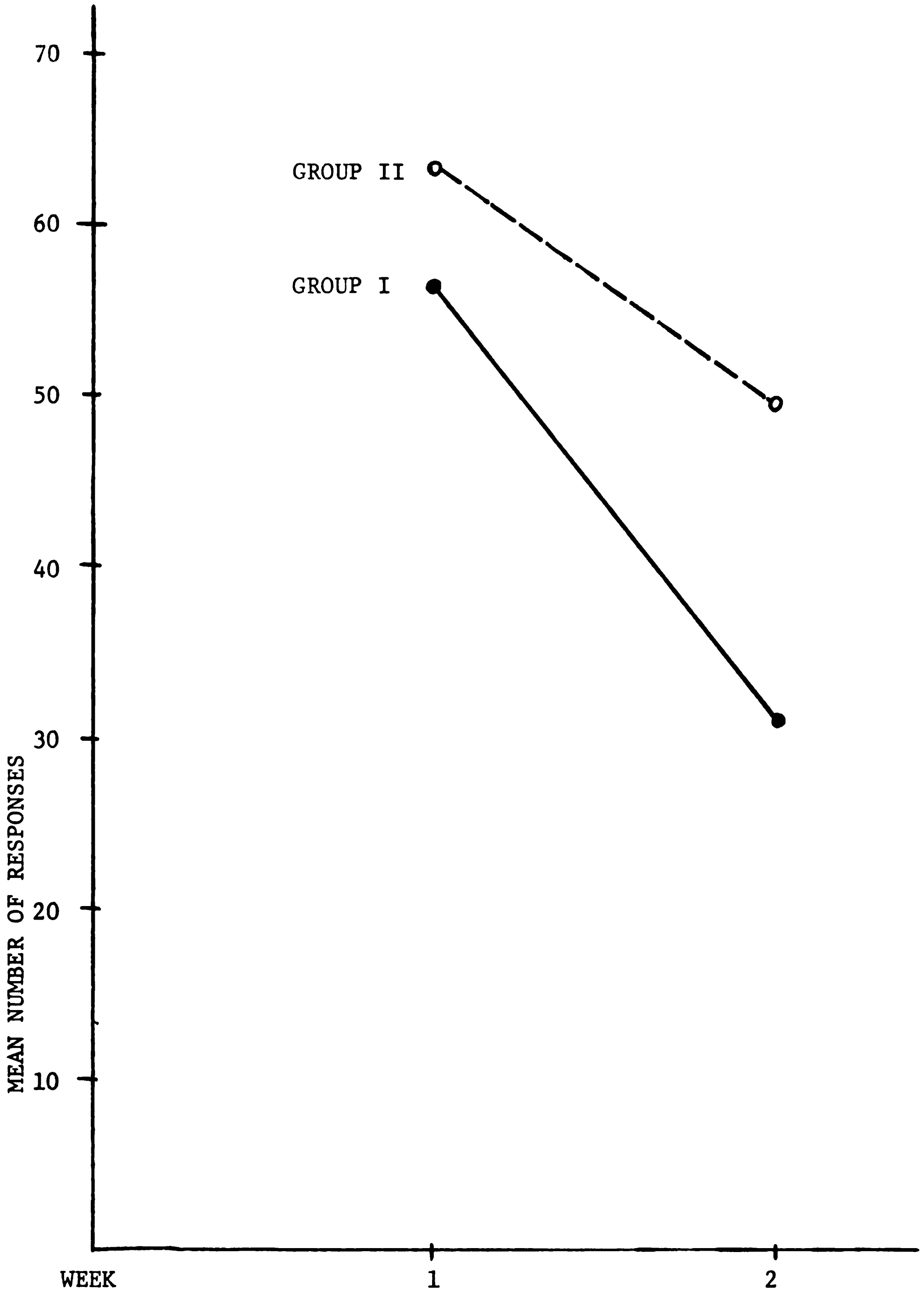

Figure 7. The mean number of spontaneous AC responses made by group I and group II Ss during week 1 and week 2 (a redrawing of figure 6).

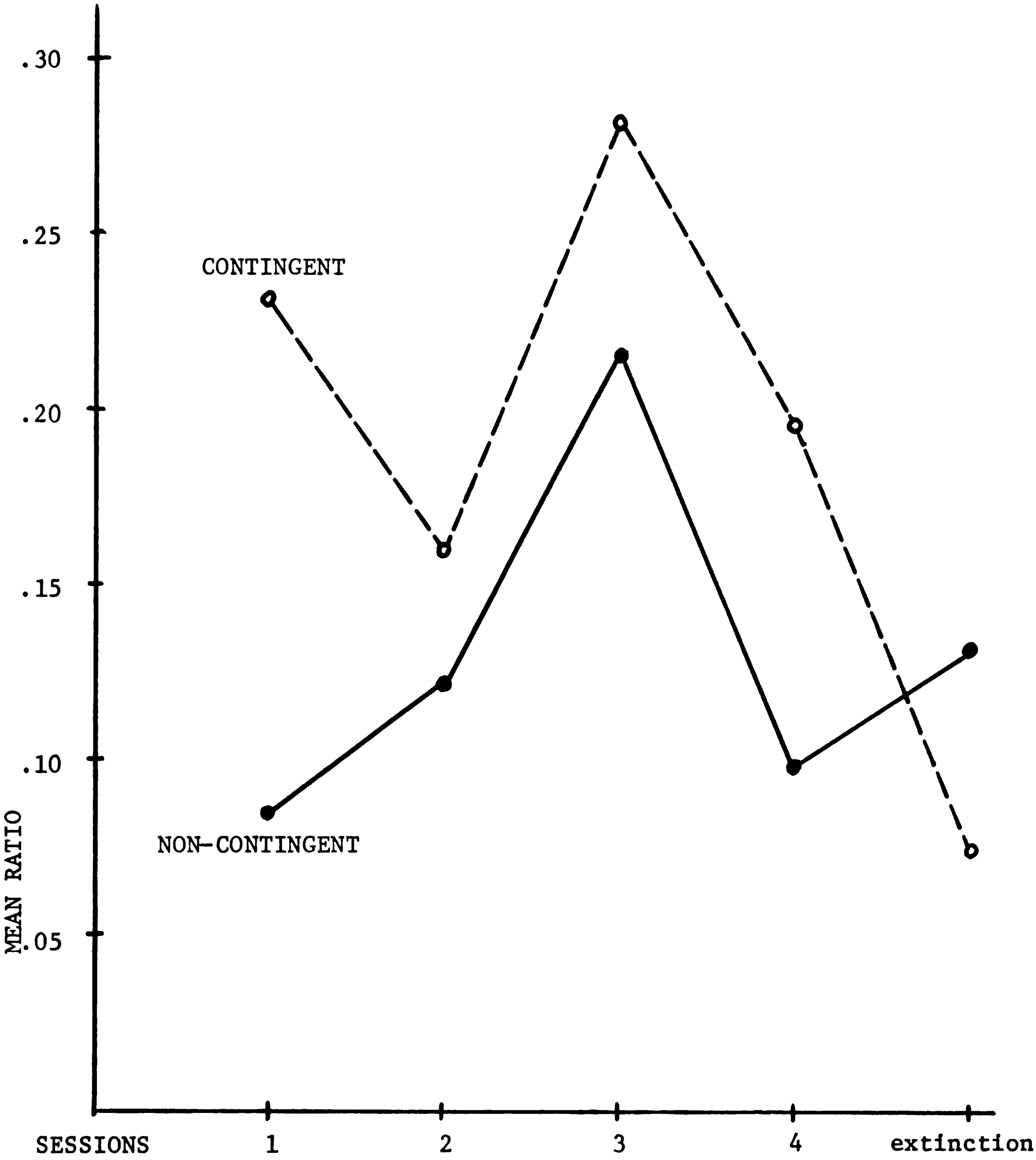

Figure 8. The mean ratio (number of spontaneous criterion responses / total number of spontaneous responses) during contingent and non-contingent sessions.

Insert Figure 9 about here

The simple effects for both the contingent and non-contingent sessions were not significant. For the contingent reinforcement sessions there was a slight effect ($F_{(4,60)} = 1.76$, $p < .25$) which was contributed to by slight linear ($F_{(1,60)} = 2.21$, $p < .25$) guadratic ($F_{(1,60)} = 1.94$, $p < .25$) and cubic ($F_{(1,60)} = 1.52$, $p < .25$) trends. This reflects the high ratio for the third session and the low ratio for the extinction session. Newman Keuls analysis did not indicate any strong differences between individual sessions ($p > .05$).

Comparisons with Baseline and Extinction Data

To compare the contingent conditioning sessions with baseline data from the screening session, first a two-way analysis of variance was run. The effect of the sessions (baseline, 4 contingent, extinction) and group were determined, then orthogonal comparisons were made to compare the baseline data with the 4 conditioning sessions. There were significantly more criterion responses and spontaneous criterion responses during the screening session than during the contingent reinforcement sessions (for criterion responses, $F_{(1,36)} = 8.26$, $p < .01$; for spontaneous criterion responses, $F_{(1,36)} = 7.89$, $p < .01$). This decrease in the desired response tends to argue against conditioning, but it could still be possible to show that an operant conditioning procedure slows the normal decrease in criterion responding. None of the measures of total responding showed a significant change from the screening session to the contingent reinforcement sessions. Similarly there was no significant difference for the ratio measure of the

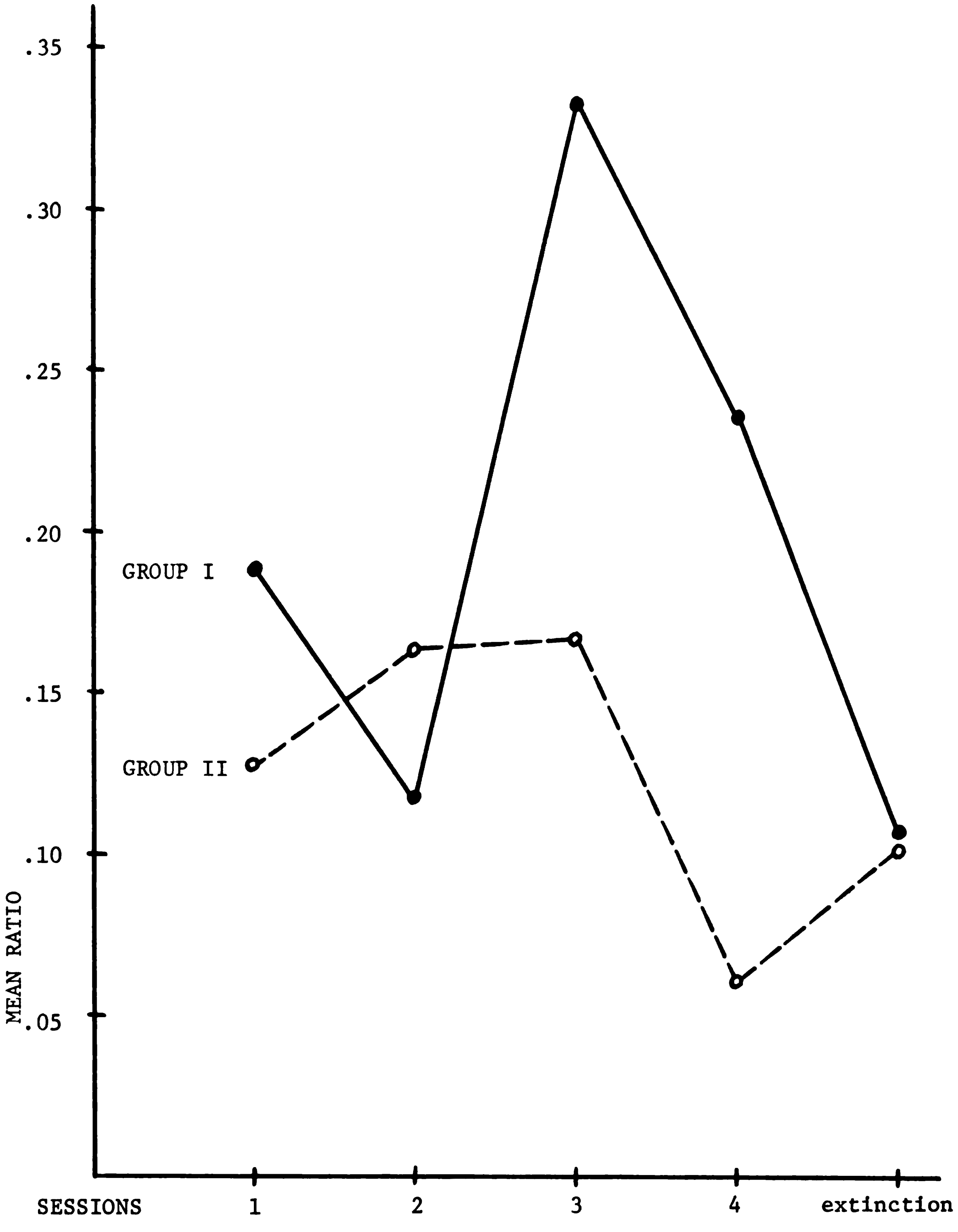

Figure 9. The mean ratio (the number of spontaneous criterion responses / number of spontaneous responses) for group I and group II Ss.

production of criterion responses.

To compare performance during the reinforcement sessions with performance during the extinction sessions, orthogonal comparisons were made. These comparisons contrasted performance during the four reinforcement sessions (either contingent or non-contingent) with performance during the extinction session which followed. This was done for each of the variables previously analyzed. For the number of criterion responses (total or spontaneous) the number did not differ for the contingent sessions and extinction or for the non-contingent sessions and extinction. There were, however, more criterion responses on the average during contingent reinforcement than during non-contingent reinforcement or extinction. This can be seen in Table 8a, 8b. For the contingent reinforcement week, there is an almost significantly higher total number of responses during extinction than during the reinforcement sessions ($F_{(1,60)} = 3.98$, $p < .10$). This may reflect some frustration or increased arousal with withdrawal of the reinforcer after S̲ has learned the task.

When only spontaneous responses are considered, the effect reaches significance ($F_{(1,60)} = 7.55$, $p < .01$). This increase in total responding during extinction has the effect of depressing the ratio. However, during contingent reinforcement the ratio is above what it is during non-contingent reinforcement. Therefore the ratios are significantly different for the contingent reinforcement sessions than for the extinction that follows ($F_{(1,60)} = 4.68$, $p < .05$). These can be seen in Tables 8c, d, e. There is an increased ratio during conditioning which drops during extinction -- the drop being primarily due to an increase in total responding.

Insert Table 8 about here

Comparisons of Elicited and Spontaneous Responses

The responses elicited by the reinforcer were compared to the spontaneous responses. While it was not expected that no elicited responses would meet the criterion, it was expected that there would be no more elicited responses than spontaneous responses meeting the criterion and that there might be less. This is central to the argument that the criterion responses are not elicited by some somatic change. For if more elicited responses met the criterion, it could not be claimed that the criterion responses were independent of somatic mediation. To test this, the proportion of criterion elicited responses and of criterion spontaneous responses was calculated separately for contingent and non-contingent reinforcement sessions. Extinction sessions were not included since there was no reinforcement to elicited responses. Results of this can be seen in Table 9.

Insert Table 9 about here

An analysis of variance was performed for these proportions of criterion responses. There was a significantly higher proportion of criterion responses within the spontaneous responses than within the elicited responses ($F_{(1,120)} = 5.84$, $p < .05$). This was as expected and indicates that elicited responses are less likely to be criterion responses than spontaneous responses are. The effect for the contingency of the reinforcer was also significant ($F_{(1,120)} = 3.94$, $p < .05$).

Table 8

Comparisons Between the Means for Contingent Reinforcement (C) Sessions, the Means for Non-Contingent Reinforcement (NC) and the Extinction Data for (a) the Number of Criterion Responses, (b) the Number of Spontaneous Criterion Responses, (c) the Total Number of Responses, (d) the Total Number of Spontaneous Responses, and (e) the Ratio.

	NC	C
Acquisition Mean	8.906	11.500
Extinction	8.125	7.125

(a) the Number of Criterion Responses

	NC	C
Acquisition Mean	6.750	9.219
Extinction	6.875	6.250

(b) the Number of Spontaneous Criterion Responses

	NC	C
Acquisition Mean	75.125	58.687
Extinction	51.625	86.375

(c) the Total Number of Responses

Table 8 (Con't)

	NC	C
Acquisition Mean	48.437	46.937
Extinction	45.750	77.625

(d) the Total Number of Spontaneous Responses

	NC	C
Acquisition Mean	.1307	.2178
Extinction	.1323	.0756

(e) the Ratio

Table 9

Proportion of Criterion Elicited Responses and of Criterion Spontaneous Responses during Contingent and Non-contingent Reinforcement

$\frac{\#\text{Criterion Responses}}{\#\text{Total Responses}}$	Elicited	Spontaneous
During:		
Contingent Reinforcement	.1191	.2162
Non-contingent Reinforcement	.0895	.1315

with the proportion of criterion responses being higher during contingent reinforcement. This confirms the result seen earlier regarding criterion responses. There was also a significant group effect ($F_{(1,120)} = 10.99$, $p < .01$) which parallels the group effect found earlier.

DC Level

Throughout the experiment DC recordings were made in addition to the AC change measures. Changes in the DC level within sessions and across sessions may indicate changes in arousal level. A balance voltage which is less negative or even positive indicates a more relaxed state. The DC level was sampled for all sessions at five minute intervals (0, 5, 10, 15, 20 minutes). At each of these times the balance voltage level was recorded. If there was a response at the sample point, the level immediately before the response began was recorded. Similarly at the 0 and 20 minute points the level was taken before the beginning or end of the session was announced. This was done so that the DC level would reflect the baseline from which the responses deviated, rather than any spontaneous or elicited responses.

Looking at the level for the right hand, the level declined as each session progressed. The level was lower at the start of the first contingent and non-contingent sessions than at the start of the other sessions. For these first sessions the level declined steadily from the beginning to the end. The other 4 sessions' level reached a low after 10 minutes then stayed near there. For the second, third and fourth sessions the level rose just slightly by the 20th minute. During the two extinction sessions, the level rose for the 15th minute, then was back down for the 20th minute. The level was almost 1.0 mv. higher for Group II Ss (those having non-contingent reinforcement the first week) than Group I at each sampled minute. The level was just slightly higher at each sampled minute during non-contingent reinforcement than it was during contingent reinforcement.

Comparing levels across sessions indicates a slight interaction for Group I Ss. During the first sessions of the week non-contingent reinforcement produced a higher level, but by the end of the week contingent reinforcement produced a higher level. The end of the week effect during the last experimental session and the extinction session was reversed for Group II; for them non-contingent reinforcement required higher balance voltage levels. Across all sessions, Group II had higher levels. For sessions one and two, non-contingent reinforcement was accompanied by higher levels than contingent reinforcement; this was reversed for the third and fourth sessions, then true again during extinction. Similar changes were seen in the left hand.

Magnitude of Responses

Since differential responding in the right and left hands was reinforced, changes in the magnitude of the AC responses might have been observed. Responses three times as great in the designated hand than in the other hand were reinforced, so the designated hand could have shown increasingly large responses -- either absolutely, or in proportion to the responses in the other hand. Such an increase would show that conditioning not only changed the production of criterion responses but also changed the typology of the responses. To examine this, five spontaneous responses were selected from each session. This represented 10% of the average number of spontaneous responses per session

(50.49). The first response magnitude was that of the first spontaneous response after the one elicited by the "begin" announcement. Then the last spontaneous response was selected from each quartile of spontaneous responses. For example, if there were 100 spontaneous responses, the 25th, 50th, 75th, and 100th responses were selected. The last response was always the last response before the "end" announcement. When S did not give a sufficient number of spontaneous responses for this sampling technique (gave less than 5 responses), responses of zero on both hands were assigned. A ratio was made of the magnitude of the response in the designated hand divided by the magnitude of the response in the other hand.

In general, the magnitude of these selected responses dropped from the screening session to the beginning of the weeks. Then over the week it rose back to the original level and dropped for the extinction sessions. On each day of the week the ratio was higher for those Ss receiving contingent reinforcement. This effect can be seen in Figure 10. During the baseline recording, the mean ratio was higher for those Ss with the left hand designated. However, for the experimental sessions higher ratios were seen in Ss with the right hand designated.

Insert Figure 10 about here

Reasons

Subjects were asked at the end of each session and at the end of the experiment what they felt they had done to control the presentation of the slides. Three Ss repeatedly verbalized that they had no idea

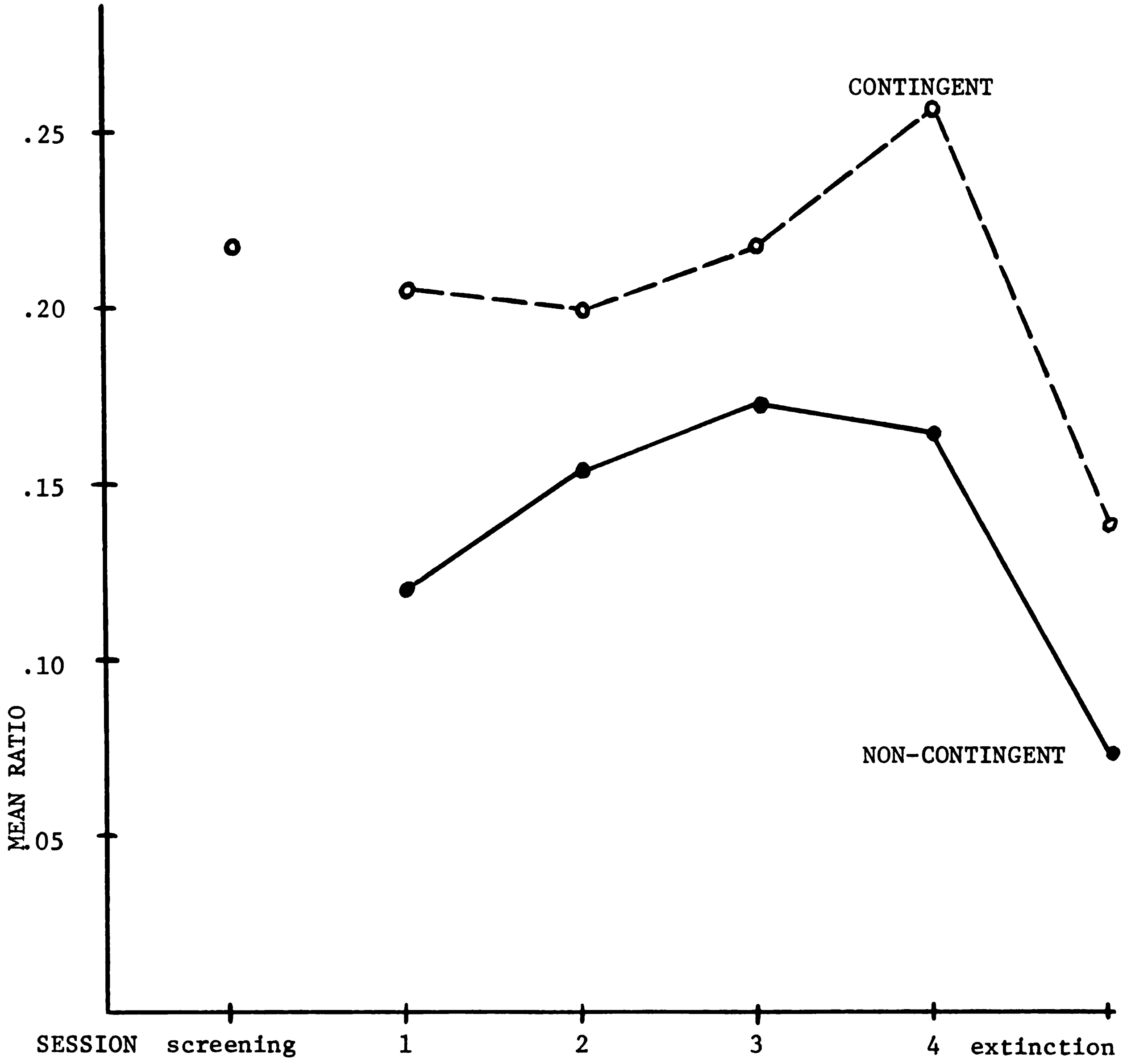

Figure 10. Mean ratio of the magnitude of the response in the designated hand divided by the magnitude of the response in the other hand during contingnet and non-contingent reinforcement sessions.

what controlled the slides except that it might have to do with thinking. All other Ss came up with more than one hypothesis over the sessions. These hypotheses included changes in respiration, alertness, concentration, eye movements, as well as suggestions regarding what they thought about to cause the slides. These included thinking about homework, sports, sexual activity, recent events in their lives and attempting to blank their mind. Two Ss specifically mentioned that the wires attached to their arms must have something to do with control of the slides. One S narrowed this down, indicating that it must be the white wire (ground). Although heart rate was not mentioned at the end of any particular session, two Ss mentioned this when asked at the end of the experiment to summarize what they thought was involved.

No S mentioned GSR, electrodermal activity, sweat gland activity, differential responding on the right and left body sides or anything which might have indicated awareness of the purpose of the experiment. The statements given at the end of the sessions are included in Appendix B.

Individual Data

The design of the present study allows comparison between Ss performance during contingent and non-contingent reinforcement to see if each S conditioned. There are two measures that can be used to determine whether or not conditioning has occurred: (1) the absolute number of criterion responses emitted or (2) the proportion of criterion responses emitted. Table 10 gives this information for each S.

Three Ss had both a larger number of criterion responses *and* a *larger* proportion of them during contingent reinforcement than during non-contingent reinforcement (#4, #5, #7). However, none of the t-tests to check this were significant because the data was from only 4 of each type of session and thus the test had only three degrees of freedom ($p > .05$). It does, however, seem that conditioning has been demonstrated for these three *S*s. They were also the *S*s receiving the highest number of correct reinforcements during the contingent period. The only other *S* receiving more than twenty correct contingent reinforcements was #2, and this *S* had a higher ratio during the contingent sessions, but approximately the same number of criterion responses both weeks. It could be that twenty reinforcers is a necessary, but not sufficient condition for operant training to take place. The reason that the one *S* with more than 20 reinforcers did not condition could have been his lack of concentration or of interest in the task for this *S* was one of the three who did not come up with more than a single suggestion as to how the slides were controlled. The other two who did not come up with a variety of suggestions (#3 and #8) had higher ratios during the contingent sessions, but showed no more criterion responses than they had shown during non-contingent reinforcement.

This suggests that some involvement with the task that results in active hypothesizing may be necessary for conditioning to take place. Conditioning was not expected for *S*s #6 and #8 since each received less than ten correct reinforcers and indeed only the ratio indicator for *S* #8 suggested any conditioning effect. Subject #1 showed slightly more criterion responses during contingent reinforcement, but the ratio was larger for non-contingent reinforcement. Graphs of each *S*'s responding for each session are contained in Appendix C.

Insert Table 10 about here

Table 10

The Number and Proportion of Criterion Responses Emitted by Each S During Contingent and Non-Contingent Reinforcement

	Mean Number of Criterion Responses per Session		Mean Ratio (mean proportion of criterion responses per session)	
Reinforcement Session	Non-Contingent	Contingent	Non-Contingent	Contingent
Subject				
1	7.25	8.25	.1127	.0577
2	16.50	15.25	.2922	.4099
3	8.75	5.00	.1252	.1733
4	20.50	29.00	.1917	.4016
5	8.00	15.50	.0935	.2147
6	3.25	2.00	.0797	.0430
7	1.75	12.00	.0456	.2752
8	5.25	5.00	.1049	.1779

DISCUSSION

This study was designed to demonstrate operant conditioning of autonomic activity independent of somatic mediation. The possibility of mediation due to any bilateral somatic change was eliminated by conditioning differential responding on the right and left sides of the body. Some _S_s were able to learn to modify their skin potential responses while others were not. Those in whom successful conditioning was demonstrated were those who emitted a sufficient number of criterion responses and those whose hypothesizing about the experiment indicated active involvement with the study. For the group of _S_s both the number of criterion responses and the number of spontaneous criterion responses were higher during contingent reinforcement than during non-contingent reinforcement. However, neither of these differences were significant.

In order for these conditioning effects to be shown as independent of somatic mediation, it also was necessary to show that elicited responses were unlikely to be criterion responses. This was shown both for responses elicited by a variety of stimuli during the screening session and for responses elicited by the reinforcer during the experimental sessions. To show specificity of control, it was necessary to demonstrate that the conditioning procedure did not cause changes in other aspects of _S_'s behavior. There was a decline in the total number of spontaneous responses from the first week to the second, and an effect related to Group, but the contingency of the reinforcer did not affect this total responding measure. There was a decline in arousal within each session as indicated by the DC level, but this also was not related to the contingency of the reinforcer. Similarly changes in the magnitude of responding were unrelated to the contingency of reinforcement.

These are weak conclusions because the differences in criterion responding during contingent and non-contingent reinforcement were not significant. In addition, changes in the expected direction were not found in all S̲s and there was not an overall increase above the operant level. However, the differences in the number and proportion of criterion responses were all in the expected directions. While not a strong finding, this does suggest a result similar to DiCara and Miller's study (1968b) where rats were conditioned to show vasodilation in one ear and vasoconstriction in the other ear. Both studies show successful conditioning of differential responding on the right and left sides of the body.

These results suggest that conditioning under this procedure is more difficult than under other procedures with less stringent control for somatic mediation (i.e., Crider, Shapiro & Tursky, 1966; DeFran, Badia & Lewis, 1969; Fowler & Kimmel, 1962; Gavalas, 1967; Greene & Nielson, 1966; Greene, 1966; Johnson, 1963; Kimmel & Kimmel, 1963; Baer & Fuhrer, 1968; Shapiro, Crider & Tursky, 1964; Shapiro & Crider, 1967; VanTwyver & Kimmel, 1966). There are several possible explanations for this. If controls for somatic mediation are not stringent, it is likely that some somatically mediated autonomic activity will be reinforced along with the spontaneous autonomic activity. As the controls for somatic mediation become more stringent, fewer mediated responses and more spontaneous responses are reinforced. Since the direct control of autonomic activity may be more difficult than the long accepted ability to control somatic activity, conditioning may be more difficult to show with more stringent controls.

In addition, the number of reinforceable responses is cut down considerably when only those free from somatic mediation are reinforced. With this lower level of appropriate responding, conditioning may take considerably longer. Another explanation may be that the small sample of Ss included some with less conditionability and that these weakened the results. In this case, a greater number of Ss would be needed to show a group effect. A final possibility is that autonomic conditioning of operant activity is not possible and that the small effect that was seen was due to some undetected mediating somatic activity. In the light of the other studies using control for somatic mediation which show successful conditioning (including Brener & Hothersal, 1967; Rice, 1966; Schwartz & Johnson, 1969; DiCara & Miller, 1968b; DiCara & Miller, 1969b), this explanation seems unlikely.

To determine finally if such conditioning is possible in humans when sources of somatic mediation are controlled for, additional studies will be needed. Additional use of the design employed in the present study may help answer this question since it controls for bilateral somatic mediation. Future experimental work should make use of the most powerful reinforcers possible to maximize the change of S's learning. In addition future work should consider either selecting responses with a higher operant level or continuing the study for a greater number of sessions. In these ways the liklihood of successful conditioning is maximized. It might also be possible to control for unilateral somatic mediation by working with Ss previously trained in neuromuscular relaxation. Learning will not be truely demonstrated until increases over the operant level are shown and until acquisitions and extinction curves approximate those found for somatic, voluntary operants.

While work continues on the theoretical question of whether operant and classical conditioning really do have separated domains, a more practical question should not be ignored. What is the best technique for modifying autonomic activity? It could be that such activity can be more readily and more permanently modified when somatic mediation is allowed. For example, lowering blood pressure may be most successfully accomplished by teaching muscular relaxation. Or it could be that conditioning independent of somatic mediation is more effective and/or long lasting.

LIST OF REFERENCES

LIST OF REFERENCES

Ascough, J. C. Increase and decrease in heart rate as a function of operant verbal conditioning. Dissertation Abstracts, 1967, 28 (6-B), 2617.

Ascough, J. C. & Sipprelle, C. Operant verbal conditioning of autonomic responses. Behavior Research and Therapy, 1968, 6(3), 363-370.

Birk, L., Crider, A., Shapiro, D., & Tursky, B. Operant electrodermal conditioning under partial curarization. Journal of Comparative and Physiological Psychology, 1966, 62, 165-166.

Black, A. H. Operant conditioning of heart rate under curare. Technical Report No. 12, McMaster University, Dept. of Psychology, October, 1967.

Black, A. H. Operant conditioning in curarized dogs. Conditional Reflex, 1967, 2(2), 158.

Black, A. H. & de Toledo, L. The relationship among classically conditioned responses: HR and skeletal behavior. Paper presented at a conference on classical conditioning, McMaster University, May 12-14, 1969.

Brener, J. & Hothersall, D. Heart rate control under conditions of augmented sensory feedback. Psychophysiology, 1966, 3, 23-28.

Brener, J., & Hothersall, D. Paced respiration and heart rate control. Psychophysiology, 1967, 4, 1-6.

Brown, C. C. & Katz, R. A. Operant salivary conditioning in man. Psychophysiology, 1967, 4, 156-160.

Bry, B. M. The operant conditioning of human EEGs. Dissertation Abstracts International, 1970, 30 (10-B), 4805.

Carroll, J. F. Instrumental conditioning of heart rate using avoidance techniques, Dissertation Abstracts International, 1970, 31 (5-B), 3015.

Church, R. M. Systematic effect of random error in the yoked control design. Psychological Bulletin, 1964, 62, 122-131.

Crider, A., Schwartz, G. & Shapiro, D. Operant suppression of spontaneous skin potential responses. Conditional Reflex, 1968, 3, 131.

Crider, A., Schwartz, G., & Shapiro, D. Operant suppression of electrodermal response rate as a function of punishment schedule. Journal of Experimental Psychology, 1970, 83, 333-334.

Crider, A., Shapiro, D., & Tursky, B. Reinforcement of spontaneous electrodermal activity. Journal of Comparative and Physiological Psychology, 1966, 61, 20-28.

DeFran, R. H., Badia, P., & Lewis, P. Stimilus control over operant galvanic skin responses. Psychophysiology, 1969, 6, 101-106.

DiCara, L. V. & Miller, N. E. Changes in heart rate instrumentally learned by curarized rats as avoidance responses. Journal of Comparative and Physiological Psychology, 1968, 65, 8-12.

DiCara, L. V. & Miller, N. E. Instrumental learning of vasomotor responses by rats: Learning to respond differentially in the two ears. Science, 1968, 159, 1485-1486.

DiCara, L. V. & Miller, N. E. Commun. Behav. Biol., 1968, 2, 209.

DiCara, L. V. & Miller, N. E. Heart rate learning in the non-curarized state, transfer to the curarized state, and subsequent retraining in the non-curarized state. Physiology and Behavior, 1969.

DiCara, L. V. & Miller, N. E. Transfer of instrumentally learned heart rate changes from curarized to non-curarized state: Implications for a mediational hypothesis. Journal of Comparative and Physiological Psychology, 1969, 68, 159-162.

DiCara, L. V. & Stone, E. A. Effect of instrumental heart rate training on rat cardiac and brain catecholamines. Psychosomatic Medicine, 1970, 32, 359-368.

Edelman, R. I. Instrumental modification of the galvanic skin response. Dissertation Abstracts, 1968, 29 (5-B), 1856.

Edelman, R. I. Effects of differential afferent feedback on instrumental GSR conditioning. Journal of Psychology, 1970, 74, 3-14.

Engel, B. T. & Chism, R. A. Operant conditioning of heart rate speeding. Psychophysiology, 1967, 3, 418-426.

Engel, B. T. & Gottlieb, S. H. Differential operant conditioning of heart rate in the restrained monkey. Journal of Comparative and Physiological Psychology, 1970, 73, 217-225.

Engel, B. T. & Hanson, S. P. Operant conditioning of heart rate slowing. Psychophysiology, 1966, 3, 176-187.

Fetz, E. Operant conditioning of cortical unit activity. Science, 1969, 163, 955-957.

Fowler, R. L., & Kimmel, H. D. Operant conditioning of the GSR. Journal of Experimental Psychology, 1962, 63, 563-567.

Fox, S. S., & Rudell, A. P. Operant controlled neural event: Formal and systematic approach to electrical coding of behavior in brain. Science, 1968, 162, 1299-1302.

Fox, S. S., & Rudell, A. P. Operant controlled neural event: Functional independence in behavioral coding by early and late components of visual cortical evoked responses in cats. Journal of Neurophysiology, 1970, 33, 548-561.

Gavalas, R. J. Operant reinforcement of an autonomic response: 2 studies. Journal of Experimental Analysis of Behavior, 1967 10, 119-130.

Greene, W. A. Operant conditioning of the GSR using partial reinforcement. Psychological Reports, 1966, 19, 571-578.

Greene, W. A. & Nielson, T. C. Operant GSR conditioning of high and low autonomic perceivers. Psychonomic Science, 1966, 6, 359-360.

Grings, W. W. & Carlin, S. Instrumental modification of autonomic behavior, The Psychological Record, 1966, 16, 153-159.

Headrick, M. W., Feather, B. W. & Wells, D. T. Unidirectional and large magnitude heart rate changes with augmented sensory feedback. Psychophysiology, 1971, 8, 132-142.

Hefferline, R. F. Learning theory and clinical psychology - an eventual symbiosis? in A. J. Bachrach (ed.) Experimental Foundations of Clinical Psychology, Basic Books, Inc., New York, 1962, 97-138.

Hothersall, D. Operant conditioning of heart rate changes in curarized rats with brain stimulation reinforcement. Dissertation Abstracts, 1969, 29 (11-B), 4399-4400.

Hothersall, D. & Brener, J. Operant conditioning of changes in heart rate in curarized rats. Journal of Comparative and Physiological Psychology, 1969, 68, 338-342.

Johnson, H. J. & Schwartz, G. Suppression of GSR activity through operant reinforcement. Journal of Experimental Psychology, 1967, 75, 307-312.

Johnson, R. Operant reinforcement of an autonomic response. Dissertation Abstracts, 1963, July-Sept., 1255.

Kamiya, J. Operant control of the EEG alpha rhythm and some of its reported effects on consciousness. In C. T. Tart (ed.), Altered States of Consciousness: A Book of Reading, 1967, 507-517.

Kamiya, J. Conscious control of brain waves. Psychology Today, 1968, 1, 56-60.

Keller, F. S. & Schoenfeld, W. N. Principles of Psychology. New York: Appleton Century-Crofts, 1950.

Kimble, G. A. Hilgard and Marguis' conditioning and learning. (2nd ed.) New York, Appleton-Century, 1961.

Kimmel, H. D. & Hill, F. A. Operant conditioning of the GSR. Psychological Reports, 1960, 7, 555-562.

Kimmel, E. & Kimmel, H. D. Replication of operant conditioning of the GSR. Journal of Experimental Psychology, 1963, 65, 212-213.

Kimmel, H. D. & Baxter, R. Avoidance conditioning of the GSR. Journal of Experimental Psychology, 1964, 68, 482-485.

Kimmel, H. D., Sternthal, H. S. & Strub, H. Two replications of avoidance conditioning of the GSR. Journal of Experimental Psychology, 1966, 72, 151-152.

Kimmel, H. D. & Sternthal, H. S. Replication of GSR avoidance conditioning with concomitant EMG measurement and Ss matched in responsivity and conditionability. Journal of Experimental Psychology, 1967, 74, 144-146.

Kimmel, E. & Kimmel, H. D. Instrumental conditioning of the GSR: Serendipitous escape and punishment training. Journal of Experimental Psychology, 1968, 77, 48-51.

Konorski, J. & Miller, S. On two types of conditioning reflex. Journal of General Psychology, 1937, 16, 264-272.

Levene, H. I., Engel, B. T., & Pearson, J.A. Differential operant conditioning of heart rate. Psychosomatic Medicine, 1968, 30, 837-845.

Lisina, M. I. The role of orientation in the transformation of involuntary reactions into voluntary ones. In L. G. Voronin, A. N. Leontieu, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (eds.) Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965.

Lovibond, S. H. Positive and negative conditioning of the GSR. Acts Psychologia, 1963, 21, 101-107.

Malmo, R. E. On central and autonomic nervous system mechanisms in conditioning, learning and performance, Canadian Journal of Psychology, 1963, 17, 1-36.

Mandler, G., Preven, D. W. & Kuhlman, C. K. Effects of operant reinforcement on the GSR. Journal of the Experimental Analysis of Behavior, 1962, 5, 317-321.

Martin, R. B., Dean, S. J., & Shean, G. Selective attention and instrumental modification of the GSR. *Psychophysiology*, 1968, 4, 460-467.

Mednick, S. A. *Learning*. Englewood Cliffs, N. J.: Prentice-Hall, 1964.

Miller, Neal E. Learning of visceral and glandular responses. *Science*, 1969, 163, 434-445.

Miller, N. E. & DiCara, L. V. Instrumental learning of heart rate changes in curarized rats: Shaping and specificity to discriminative stimulus. *Journal of Comparative and Physiological Psychology*, 1967, 63, 12-19.

Miller, N. E. & Carmona, A. Modification of a visceral response, salivation in thirsty dogs, by instrumental training with water reward. *Journal of Comparative and Physiological Psychology*, 1967, 63, 1-6.

Miller, N. E. & Banuazizi, A. Instrumental learning by curarized rats of a specific visceral response, intestinal or cardiac. *Journal of Comparative and Physiological Psychology*, 1968, 65, 1-7.

Milstead, J. R., Baer, P. E., & Fuhrer, M. J. Operant GSR conditioning using a within-*S* design. *Psychonomic Science*, 1968, 13, 215-216.

Mowrer, O. H. Preparatory set (expectancy) - a determinant in motivation and learning. *Psychological Review*, 1938, 45, 62-91.

Nowlis, D. P. & Kamiya, J. The control of electroencephalographic alpha rhythms through auditory feedback and associated mental activity. *Psychophysiology*, 1970, 6, 476-484.

Obrist, P. A., Webb, R. A., Sutterer, J. R., & Howard, J. L. The cardiac-somatic relationship: Some reformulations. *Psychophysiology*, 1970, 6, 569-587.

Plumlee,L.A. Operant conditioning of blood pressure increases and decreases in the monkey. *Psychophysiology*, 1968, 4, 507-508.

Plumlee, L. A. Operant conditioning of increases in blood pressure. *Psychophysiology*, 1969, 6, 283-290.

Razran, G. The observable unconscious and the inferable conscious in current Soviet psychophysiology: Interoceptive conditioning, semantic conditioning, and the orienting reflex. *Psychological Review*, 1961, 68, 81-147.

Rescorla, Robert A., & Soloman, Richard L. Two process learning theory: Relations between Pavlovian conditioning and instrumental learning. *Psychological Review*, 1967, 74, 151-182.

Rice, D. G. Operant GSR conditioning and associated electromyogram responses. Journal of Experimental Psychology, 1966, 71, 908-912.

Schwartz, G. E. & Johnson, H. J. Affective visual stimuli as operant reinforcers of the GSR. Journal of Experimental Psychology, 1969, 80, 28-32.

Senter, R. J. & Hummel, W. F., Jr., Suppression of an autonomic response through operant conditioning. Psychological Record, 1965, 15, 1-5.

Shapiro, D. & Crider, A. Operant electrodermal conditioning under multiple schedules of reinforcement. Psychophysiology, 1967, 4, 168-174.

Shapiro, David, Tursky, Bernard, & Schwartz, Gary E. Differentiation of heart rate and systolic blood pressure in man by operant conditioning. Psychosomatic Medicine, 1970, 32, 417-423.

Shearn, D. W. Operant conditioning of heart rate. Science, 1962, 137, 530-531.

Shean, G. D. Instrumental modification of the galvanic skin response: Conditioning or control? Journal of Psychosomatic Research, 1970, 14, 155-160.

Skinner, B. F. The behavior of organisms: An experimental analysis. New York: Appleton-Century, 1938.

Smith, Kendon. Conditioning as an artifact. Psychological Review, 1954, 61, 217-225.

Snyder, C. & Noble, M. Operant conditioning of vasoconstriction. Paper presented at the meeting of the Psychonomic Society, St. Louis, October, 1966.

Snyder, C. & Noble, M. Operant conditioning of vasoconstriction. Journal of Experimental Psychology, 1968, 77, 263-268.

Solomon, R. L. & Wynne, L. S. Traumatic avoidance learning: The principles of anxiety conservation and partial irreversibility. Psychological Review, 1954, 61, 353-385.

Stern, R. M., Boles, J., & Dionis, J. Operant conditioning of spontaneous GSRs: Two unsuccessful attempts. Technical Report No. 13, 1966, Indiana University, Contract Nonr 908-15, Office of Naval Research.

Stern, R. M. Operant conditioning of spontaneous GSRs: Negative results. Journal of Experimental Psychology, 1967, 75, 128-130.

Trowill, J. A. Instrumental conditioning of the heart rate in the curarized rat. Journal of Comparative and Physiologic Psychology, 1967, 63, 7-11.

VanTwyver, H. B. & Kimmel, H. D. Operant conditioning of the GSR with concomitant measurement of two somatic variables. *Journal of Experimental Psychology*, 1966, 72, 841-846.

Wyatt, R. & Tursky, B. Skin Potential levels in right and left-handed males. *Psychophysiology*, 1969, 6, 133-137.

APPENDICES

APPENDIX A: Explanations and Instructions to the Subjects.

APPENDIX A: Explanations and Instructions to the Subject

I would like to tape these 5 electrodes to you here, here and here (point). These don't pass any current through your body, but measure small currents produced by your body. Your task will be to remain alert and to refrain from moving. Toward the end of the half hour session you will be asked to make a few movements and you will be shown a slide of a female nude. Is this all right with you?

(while attaching electrodes) First I will clean your skin with alcohol where the electrodes will be attached. To make a good contact I will rub these sites until red. These adhesive collars hold the electrode on your skin and the jelly makes an electrical connection. There is an intercom connecting this room with the room next door where I am. If you are uncomfortable about being shut in here just tell me and I will come open the door. After a couple of minutes for adjusting the equipment I will announce the beginning of the experiment. You are to hold your hands with palms up and to remain alert. Get yourself into a comfortable position as I would like you to refrain from moving. After about twenty minutes I will give you a few additional instructions over the intercom. Any questions?

(after two minutes) Now the experiment will begin. Try to stay alert and refrain from moving for the next twenty minutes.

(after twenty minutes)

Now could you hold your breath for a short while and tell me when you let it out.

Could you please move your feet for a few seconds.

Could you make a fist with your right hand.

With your left.

Move your head back and forth for a bit please.

Breathe in and out rapidly about ten times please.

Try thinking emotional thoughts.

Try relaxing completely.

Try tensing your whole body.

(at the end) That ends this session. I'll be in in a minute.

APPENDIX B: Summaries of Statements Given at the End of Each Session in Response to Queries About How the Subject Did and How He Controlled the Slides.

APPENDIX B: Summaries of Statements Given at the End of Each Session in Response to Queries About How the Subject Did and How He Controlled the Slides.

Subject 1

NC1 nothing, baffled

NC2 did better, yesterday mind was wandering, today I concentrated on what I saw besides the -- on the surroundings and on the girl

NC3 --

NC4 theory didn't work too hot, tried being calm, not paying attention. Yesterday I was tense, alert; the day before, tired with my eyes shutting; today I was first alert and staring at the slides, then relaxed

E didn't do too good

C1 just thinking, relaxing

C2 I did pretty good, it is breathing or respiration

C3 decided it was not constant breathing, but could be because I was tired today

C4 did a little better, I'm still vague

E it's steady or hard breathing, deep concentration or no concentration. I got most pictures when my mind was empty

Subject 2

NC1 none

NC2 I've got no idea

NC3 got about ten slides, don't know

NC4 got 7 slides

E --

C1 are the slides in any order?

C2 got one slide, have no idea

C3 no idea

C4 --

C5 no idea. I think it had to do with thought

Subject 3

NC1 it's not moving, maybe it's thinking

NC2 I still can't figure it out, I didn't get quite as many as yesterday

NC3 did real good, then pooped out, I don't have it figured out; did pretty good, I don't know, I don't think about the slides or anything in particular

E --

C1 it was slow, not too many pictures, no pictures

C2 none again

C3 --

C4 --

E no ideas

Subject 4

NC1 it's sex or breathing

NC2 it's thinking sexual things

NC3 got quite a few slides, I don't know what controls them. I avoided thought of sex, tried thinking about schoolwork

NC4 it may be keeping an active mind, thinking about stimulus, rather than sex

E I didn't do anything different, but there were no slides

C1 it might be respiration or movement; I got a slide for moving arm; it may be a combination (he was asked not to move).

C2 --

C3 got about twenty, didn't do anything different

C4 I did about the same. It might be respiration, eyeblink or movement

E I don't think I controlled it, what I did did not seem to have any effect. If it is me it is respiration or eye movement. The purpose may be to measure heart rate or pulse rate

<u>Subject 5</u>

C1 nothing, it might be movement of the eyes

C2 got more pictures. When I get excited, it sends impulses to the wires

C3 no better today. Maybe it is the white wire or maybe you just say that to keep me alert

C4 Can't figure it out; it must be the wires. I tried thinking, but got only two pictures, tried sitting and staring, tried doing math problems

E didn't do too well

NC1 did better. I looked at the screen and didn't think about it, but just knew it would come on

NC2 --

NC3 it's positive thinking, when you concentrate, the wires give off energy and convert it and it goes to something else that makes the projector work

NC4 didn't do as well as yesterday, did the same thing

E didn't do too well. It's concentration, not on the slides, but just that there might be slides. It must have been an in-depth study of perversion, well, of concentration

Subject 6

C1 tried concentrating on sex activity, sports, and halucinatory colors

C2 I'm not sure, thinking sexual thoughts, I closed my eyes to concentrate

C3 I was thinking about taking my wife to work and crossing the picket line

C4 I got five slides, tensed myself and got a slide just before I stopped

E not very well, didn't get any slides

NC1 got at least twenty, was completely relaxed, tried taking my mind away from everything

NC2 got a whole bunch of slides, blanked mind, but mind was too blank. I tried tensing up before

NC3 must have been something, got quite a few. I tried, but nothing worked

NC4 got a whole bunch, relaxed, thinking, breathing. When I took deep breaths and let them out I got a slide

E it must be completely stopping your mind, not thinking; keeping breathing and heart rate in rhythm (purposely) a learning experience to see if we could learn to control our bodies

Subject 7

C1 when mind wanders

C2 I did better by twice, mind wanders and thinks cognitively, thinks about pictures

C3 didn't do too well

C4 got one more than yesterday, let my mind wander, don't know

E --

NC1 nothing

NC2 did excellently, don't have any idea

NC3 did thing plus more, keep mind busy and that produces them, not thinking on any one particular thing

NC4 keep thinking, not about the slides though. It must be physiological because of the wires -- electrical like slowing or speeding body pace

E I may be overtired, aware, not at ease today (purpose?) to find out about the body

Subject 8

C1 no idea

C2 --

C3 got five slides, tried remaining calm, thinking about slides

C4 no idea

E --

NC1 I got twenty-one slides, will tell you tomorrow if same technique works

NC2 I got eighteen slides

NC3 I got twenty-four slides, no idea

NC4 got twenty, don't really have an idea

E no idea

APPENDIX C: Number of Total Responses and Criterion Responses (Total, Spontaneous and Elicited) for Each Subject for Each Session.

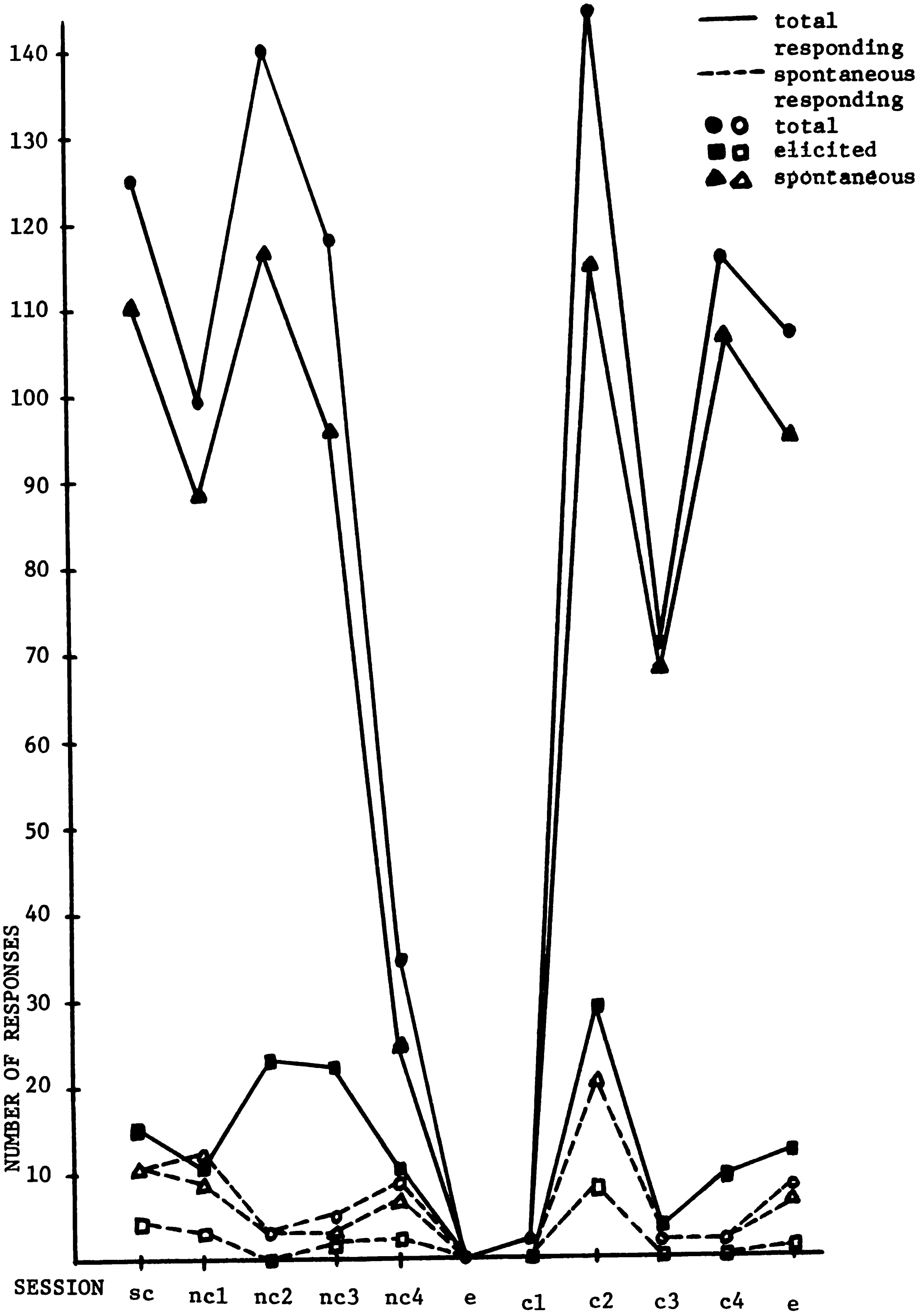

Figure A1. Responding for S # 1.

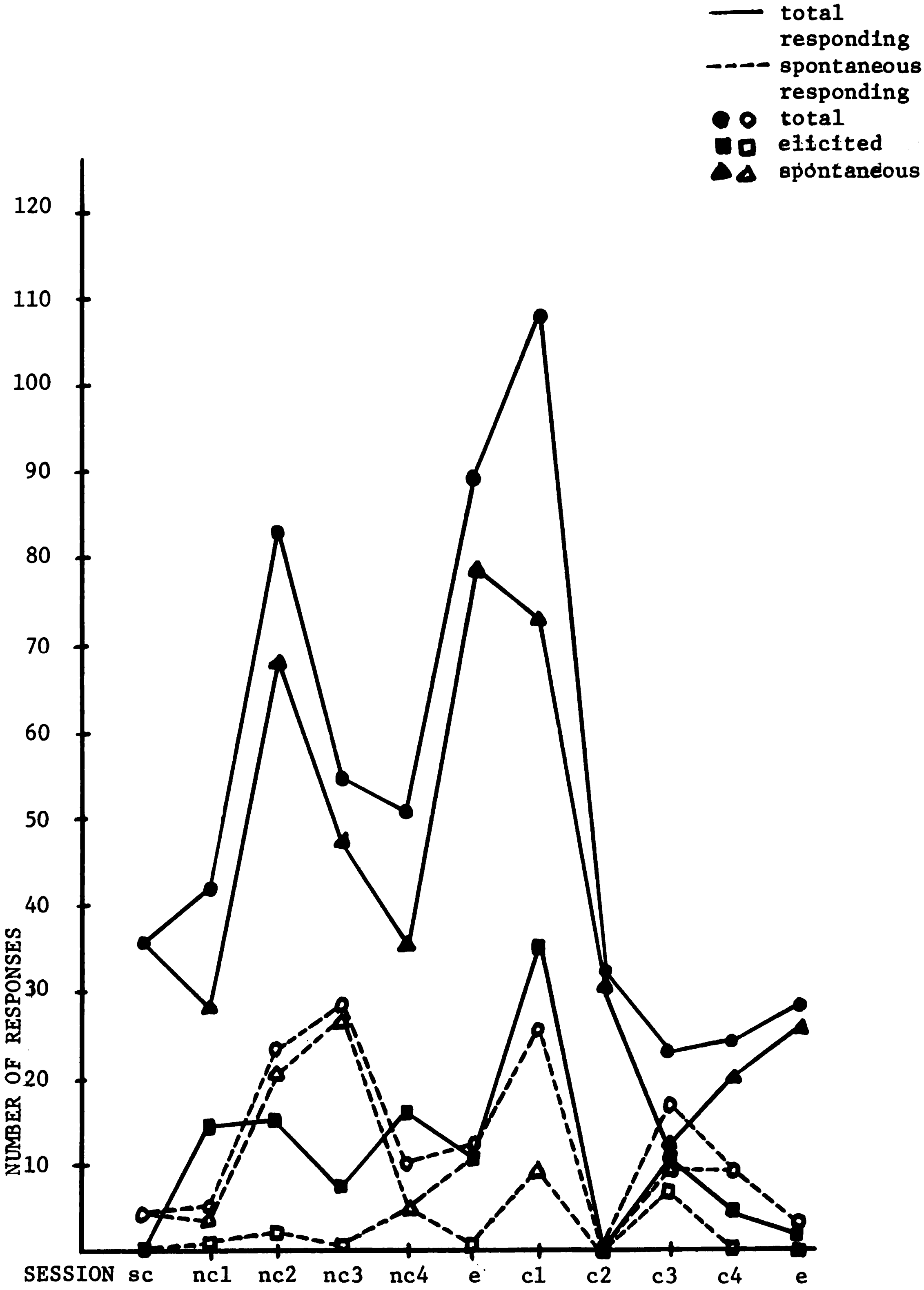

Figure A2. Responding for S # 2.

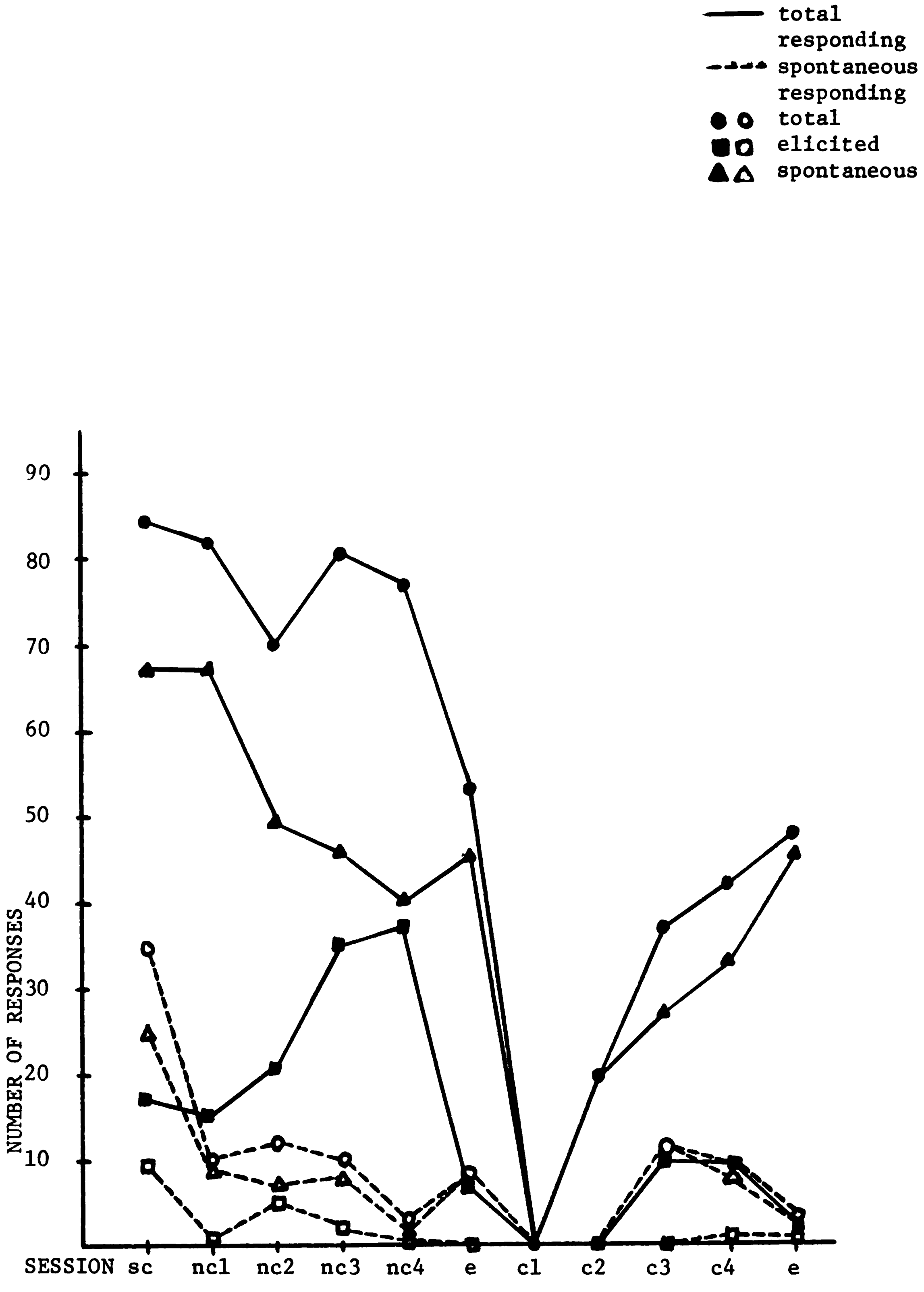

Figure A3. Responding for S # 3.

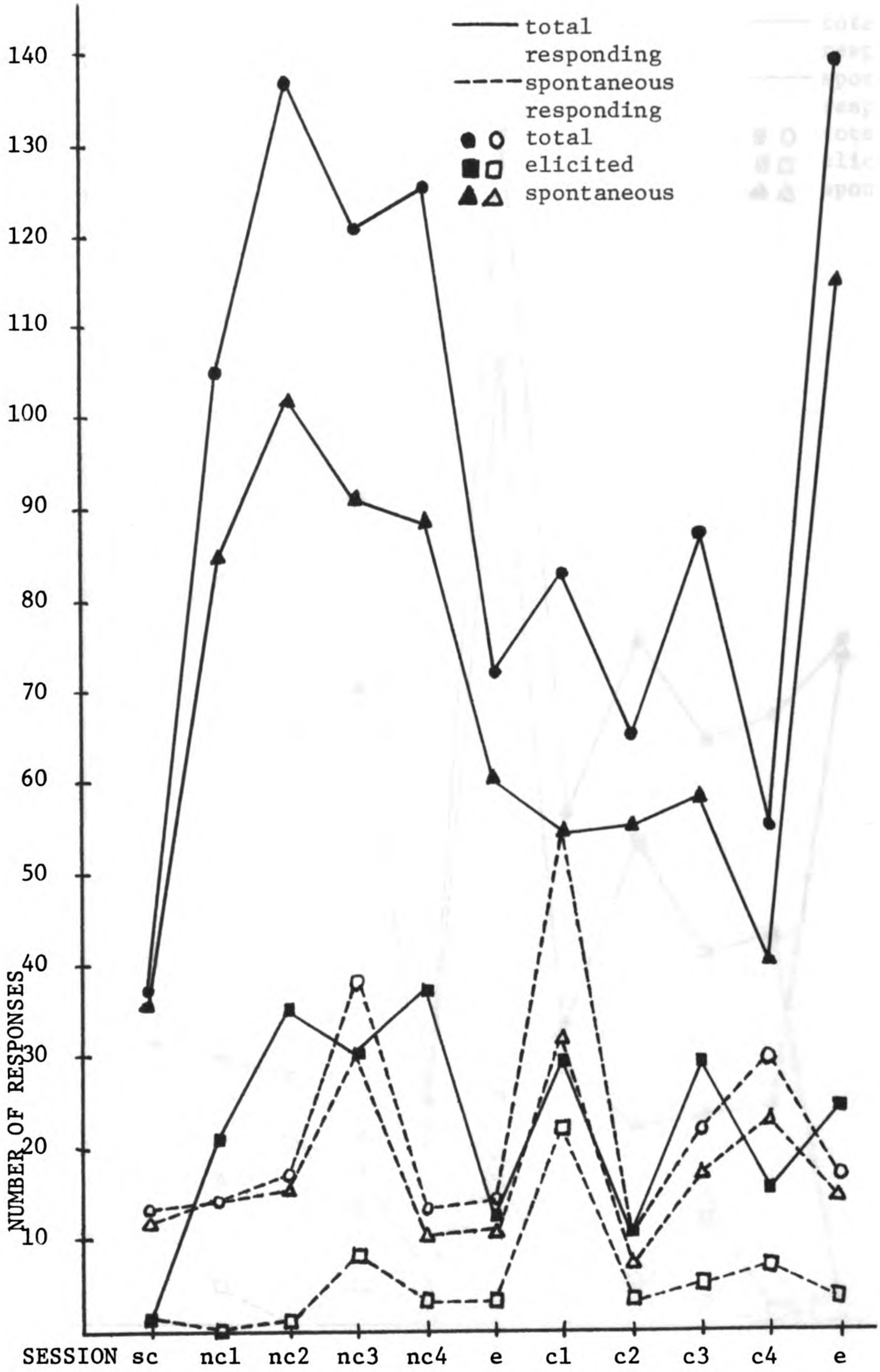

Figure A4. Responding for S # 4.

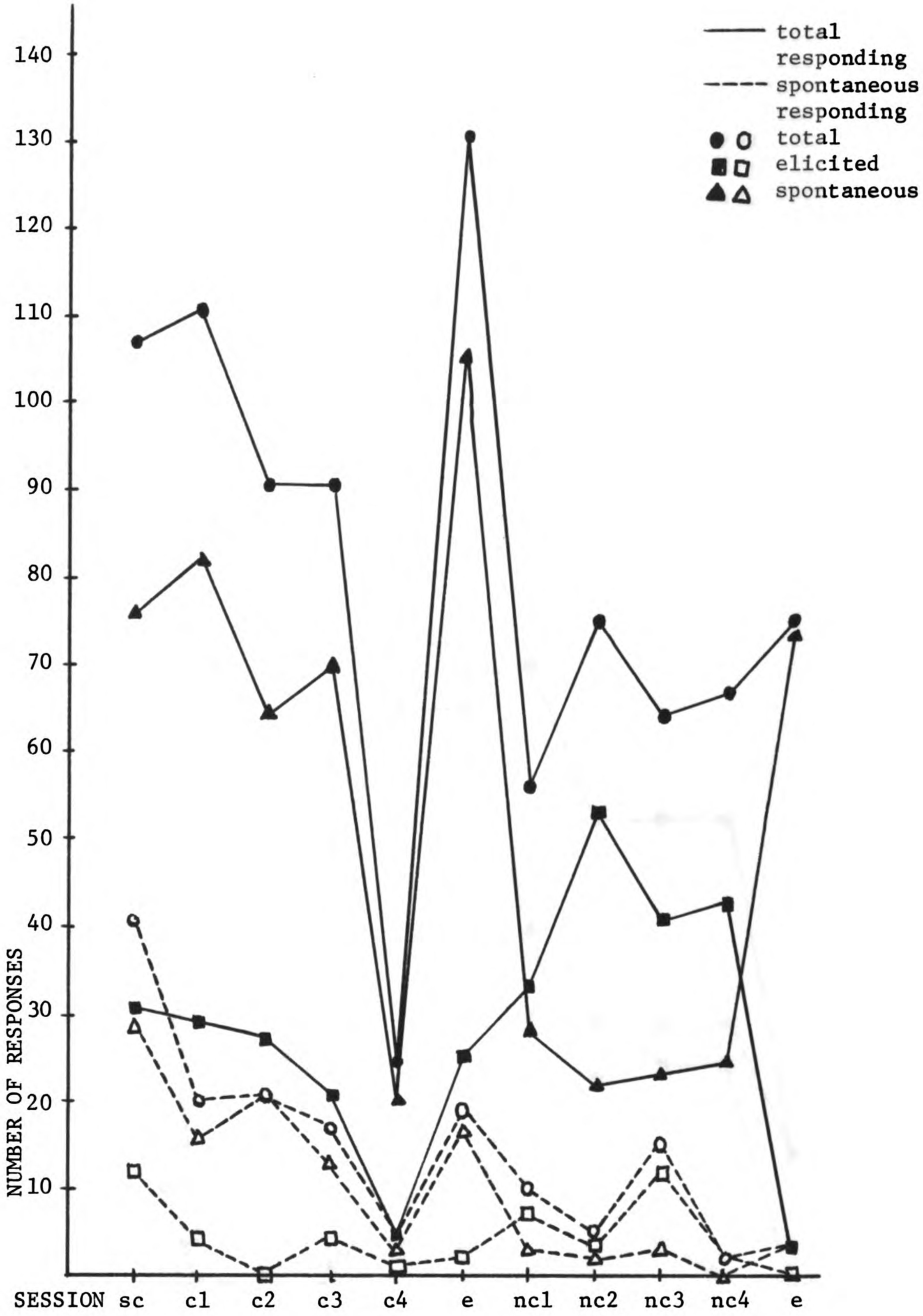

Figure A5. Responding for S # 5.

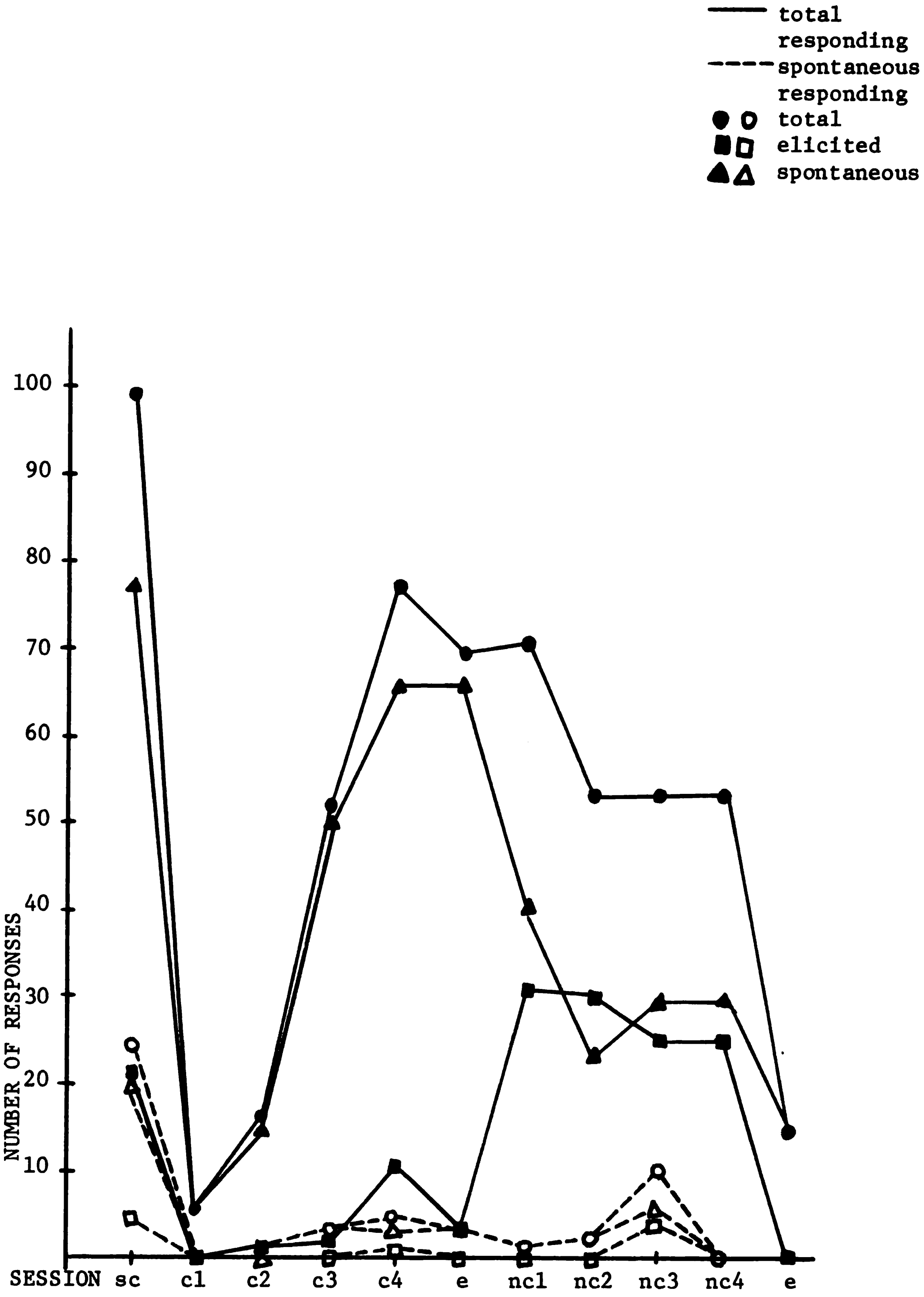

Figure A6. Responding for S # 6.

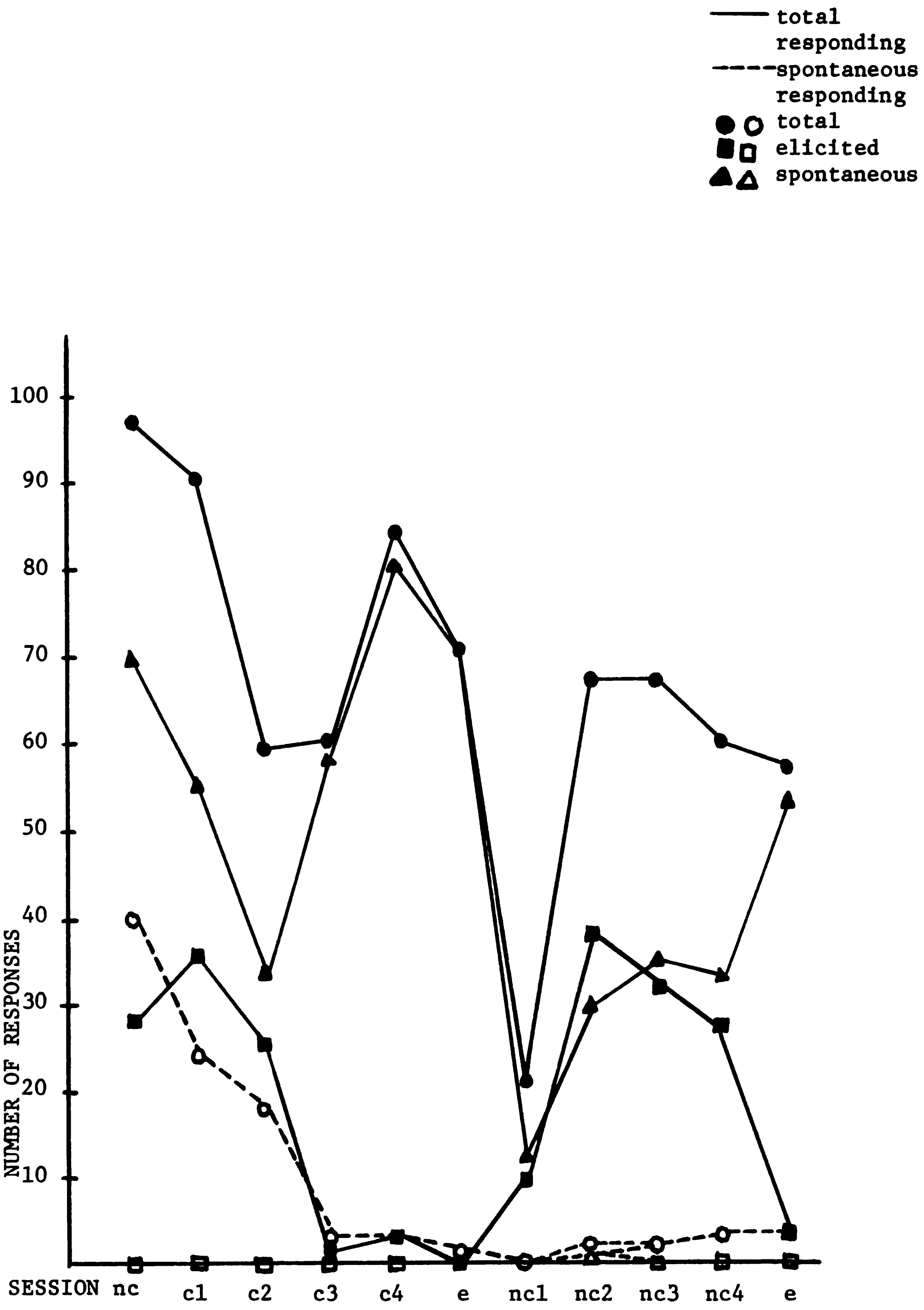

Figure A7. Responding for S # 7.

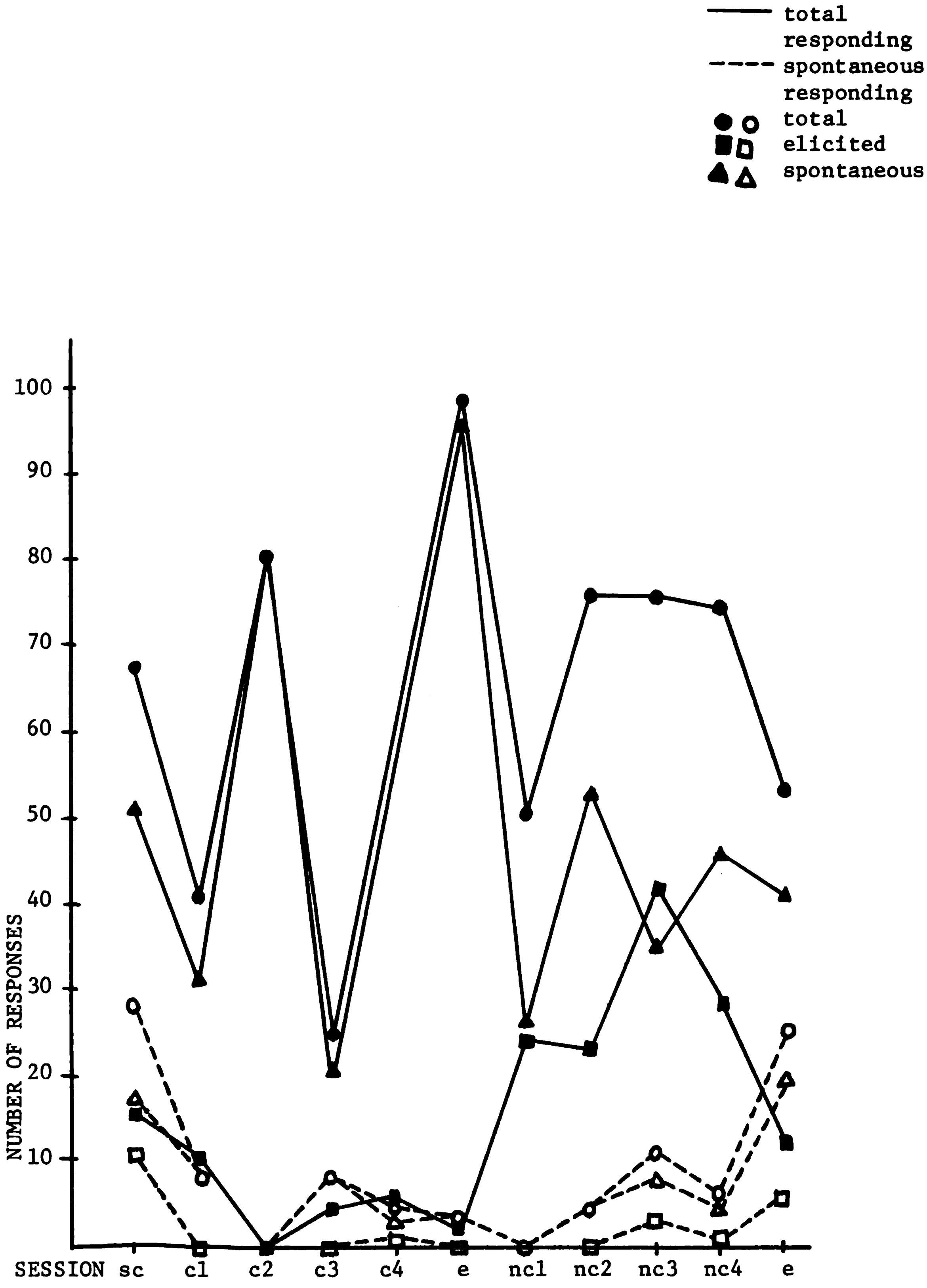

Figure A8. Responding for S # 8.