Differential Reinforcement of Semantically Conditioned Responses: Transfer Effects During Interrogation

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Brief summaries of the research described in the pages to follow have been included in progress reports to the Office of Naval Research.

We wish to express our appreciation for the assistance and advice provided by Dr. Robert M. Stern during the course of the three present experiments.

I Summary

Early in his studies of somatic responses the late Professor R. C. Davis (1955, 1) wrote:

> ...somatic responses abound. One has but to observe them on a set of measuring instruments to believe that they are by far the most numerous responses of the organism. It is clear that any overt response, vocal utterance, or bodily movement, is surrounded by a wide penumbra of them, and it may not be too bold a guess to say that whenever there is any evidence of a stimulus affecting the individual, something in his periphery or viscera is set into motion.

During the course of our research on factors affecting somatic responses it has become apparent that one of the most interesting is the process by which words and other linguistic stimuli gain control of the responses through semantic conditioning. The three experiments described in the present report were designed to study certain characteristics of semantically conditioned somatic responses and to test our ideas about ways in which such responses might be involved in and put to practical use in the detection of deception. Further studies presently under way extend the present series by answering questions which the latter has raised and by linking this form of control of somatic responses, i.e., via semantic conditioning, to research in our laboratory on other forms of control, e.g., changes in biochemical events induced by drugs.

In the present experiments we started with somatic responses which had already been socially conditioned to the concepts of "true" and "false". If these responses behaved as conventional conditioned responses, it should be possible to alter their respective magnitudes by the use of differential reinforcement. Our earlier research had demonstrated that a loud auditory stimulus, e.g., 500 cps. at 115 db. for 4 sec., was effective in eliciting changes in somatic responses. This information was put to use by employing such a loud

tone as the UCS in a differential reinforcement procedure in which false statements were followed by the tone, while true statements were followed by a small monetary reward. In order to control for the possibility that somatic responses might occur merely as sensitization to the auditory stimulus per se, the research design included a control group who were exposed to the same amount of stimulation as the main experimental Ss, but for whom the occurrence of the loud tone was not paired with false answers i.e., it appeared randomly dispersed throughout the period of differential reinforcement.

Our results show that the differential reinforcement procedure was effective in increasing differences between somatic responses to true and false statements, although not all the somatic measures were equally affected. The major test of the effectiveness of the procedure was in terms of whether transfer occurred between the period of selective reinforcement and a period immediately following during which the reinforcement was omitted; the results showed that significant transfer effects did indeed occur, but not for all the somatic measures studied. During this test period accuracy in detecting false statements was superior for Ss exposed to the differential reinforcement procedure.

One of the most serious problems involved in the use of semantically conditioned somatic responses in interrogation arises from the fact that a sophisticated or trained S can use "confusional tactics" to confound the recordings of somatic responses to critical and buffer questions. In our second experiment we found that such tactics can be very effective. However, there was some evidence that the use of our differential reinforcement procedure made the differences between responses to true and false statements more resistant to these tactics.

In the last of these three basic experiments we demonstrated that the auditory stimulus used as the UCS was effective at high, but not low, intensities. The properties of the loud tone to elicit changes in somatic responses were basic to its role as a reinforcer; the cue-value of an auditory stimulus following false statements was in itself not sufficient to influence the subsequent magnitudes of somatic responses.

II GENERAL INTRODUCTION

The present report describes the first three experiments in a series designed to study factors affecting the semantic conditioning of such somatic responses as: respiration, cardiac changes, galvanic skin responses, skeletal muscle responses and gastrointestinal activity. Earlier research in our laboratory under Contract Nonr 908-15 has been oriented toward studying the nature of somatic responses, how they are affected by changes in external stimulation and by changes in biochemical events induced by drugs. During these studies it has become clear that somatic responses are particularly sensitive indicators of changes in the stimulus environment, that certain types of change may serve as unconditioned stimuli in eliciting the responses, and that at least certain of the responses may readily become conditioned to stimuli with which they have not previously been associated. Among the latter are words and other linguistic stimuli which may serve as conditioned stimuli in semantic conditioning.

Semantic conditioning has been defined (Razran, 1961) as "...the conditioning of a reflex to a word or sentence irrespective of the particular constituent words of the sentence: that is, conditioning to meaning..." It is possible to interpret the conditioning of responses to words and other linguistic stimuli early in life as being dependent upon the mechanisms of simple classical and instrumental conditioning and to regard some of these as persisting as simple CRs throughout adult life. However, this is obviously only a part of the more complex properties which language clearly evidences. A number of experiments (Razran, 1939, 1949a and 1949b; Riess, 1940, Schwarz, 1948 and 1949; Volkova, 1953; Krasnogorsky, 1954; Lacey and Smith, 1954, Markosyan, 1957, Marushevsky, 1957; Luria and Vinogradova, 1959; and others) have reported that CRs established to a particular linguistic stimulus will generalize to other linguistic stimuli which have meaningful links to the original CS. Luria and Vinogradova (1959) have referred to stimuli linked in this way as constituting "a definite system of connexions". They have pointed out that "... owing to this, words included in past experience in a system and having the character of synonyms, begin 'on the spot' to provoke the same reaction, while words linked on an outward sound basis are braked and practically inactive".

In the experimental analysis of semantic conditioning investigators, including those referred to in the preceding paragraph, have tended to use somatic responses as objective indicators of the conditioning process and of generalization of CRs once established. The responses of choice have included salivary, galvanic skin and vascular reactions, change in light-sensitivity of the dark-adapted eye, depression of electrical activity of the brain and blood coagulation reactions. Interest in these variables within the context of semantic conditioning has made it clear that: "An important phase of the interaction of verbal with nonverbal conditioning is involved in the mechanism of the genesis of verbal control of somatic and visceral reactions (Razran, 1961)."

Our interest in the stimulus control of somatic variables led us to re-examine some of our earlier studies in this general context of semantic conditioning. It seemed possible that certain results might be accounted for in terms of the generalization of somatic CRs within a "system of connexions", to use Luria and Vinogradova's expression, in which the meaningful links among a variety of stimuli arose from a general concept in terms of which the stimuli were being evaluated by the subjects. The particular experimental situation under consideration was one in which questions constituted the linguistic stimuli to which true or false responses could be given verbally or by pressing one of two response buttons. Protocols following the experiment provided information about which of the responses had been true and which false. During each stimulus-response sequence records were also obtained of activity in several somatic response systems. Analysis of data from these experiments failed to show relations between the somatic responses and any phonetic, grammatical, or other characteristic of the stimuli per se. On the other hand, differences were found between somatic responses associated with true and false answers.

In none of the earlier experiments had there been an attempt to condition somatic responses to the concepts of true and false. Presumably the concepts had been developed earlier in each S's life history and had acquired, through the processes of conditioning, the capacity to affect somatic responses differentially. If this were the case, the details of conditions under which the concepts developed and their associations with somatic responses acquired would be expected to differ from person to person, thus providing an important source of individual differences in responses among Ss in the type of situation employed in our experiments. Another source of individual differences could be variations in the somatic response systems arising genetically. It also seems plausible that, once established, the somatic CRs could be altered by new conditioning, suppressed by competing stimulus-response units, and extinguished by repeated presentation of the stimulus without reinforcement.

These considerations suggest several directions in which further experimental analysis of the semantic conditioning of somatic responses to such general concepts as "true" and "false" might proceed. In the present three experiments we chose to begin by studying the transfer effects of a period during which somatic responses to these concepts were differentially reinforced to a test period in which reinforcement did not occur. More specifically, we exposed our experimental Ss to a series of trials in which false responses to questions, as the linguistic stimuli, were reinforced by a loud tone, which served as the unconditioned stimulus for the somatic responses recorded; true answers were reinforced by a small monetary reward. The questions were of such a nature that the truth or falsity of answers to all of them was obvious to both E and S; the specific questions are given in Appendix A. These differential reinforcement trials were followed immediately by another series of questions to some of which only S could know the truth or falsity of his answers and the somatic responses to which were never reinforced. Control Ss received the same amounts of "reinforcement" as the experimental Ss during the differential reinforcement trials, but the "reinforcement" was presented randomly, i.e., it was not contingent upon the truth or falsity of the responses to the questions. Control and experimental Ss underwent the same treatment during the subsequent test trials. Our hypothesis was that the prior reinforcement of semantically conditioned responses would significantly augment the somatic reactions to false responses during the test period, although we expected that conditioning during their earlier life history would have been sufficient to produce some differential somatic responses to true and false responses even in the control Ss. Our second experiment was designed to study effects of deliberate attempts by S to interfere with the conditioned somatic responses during the test phase of the procedure and the third, with the role of the auditory stimulus as a reinforcer during the differential reinforcement trials.

In addition to the contributions it may make to psychology as a scientific discipline, semantic conditioning has potential practical applications. Earlier research in our laboratory (Ellson et al., 1952; Davis, 1961) provided results which suggested to us that the general model upon which this form of conditioning is based might be applied to further development of procedures for the detection of deception during interrogation and, at the same time, introduce into the study of deception some basic psychological theory, which Orlansky (1964) has described as so sorely lacking. Therefore, we designed the three present experiments within the general context of an interrogation situation. The specific procedures were tailored to meet the requirements of laboratory conditions in which university undergraduates served as Ss. The attempt was to provide as realistic a setting as possible; it benefited from experience gained in the previous studies (Ellson et al., 1952; Davis, 1961). Clearly the procedure must be refined and validated under conditions in which it might be put to practical use for purposes of interrogation. We believe that the rationale underlying the procedure and the results obtained in the three experiments to be described suggest such refinement and validation to be warranted.

The report begins with a description of the general method used in the three experiments. It then proceeds to consider the experiments in detail. Since the three experiments are so closely interrelated, the discussion of results is integrated into a final section.

III GENERAL METHOD

The general method employed was similar in the three experiments. It is described in this section under three major headings: apparatus, procedure, and measures of somatic variables.

A. Apparatus

During Phases 2 and 3 described below Ss were seated in an armchair in a sound-deadened, electrically-shielded and air-conditioned room. On the modified chair arm was a two button response panel, which provided for the two voluntary response contingencies of "yes" and "no", and a counter which could be pulsed from the control room. To S's right, about two feet away, was a tone generator calibrated to deliver a 500 cps. tone at 115 db. for 4 sec. duration. A lantern slide projector was used to present the stimulus questions; this was operated in the control room and directed through a window onto a screen in the experimental room.

Three somatic responses were recorded: the electrocardiogram, galvanic skin response, and respiration.[1] Using a paper speed of 3 in./sec. approx., recordings of the electrocardiogram were taken using the Lead II arrangement; Ss skin was rubbed with abrasive saline paste before attaching 0.5 in. diameter silver electrodes to the right arm and left leg. GSR electrodes were of the $Zn\text{-}MnO_2$ type, in a Plexiglas cup with contact pads of saline-soaked cotton; resistance change to a 30 microamp. imposed current was recorded on a servo-graphic recorder, paper speed 2 mm/sec. The transducer for recording changes in breathing consisted of a small-caliber, soft rubber tube with a mercury core the inspiration/expiration pattern caused varying resistance to a small current passed through the mercury, variations being recorded on an ink-writing

[1]Plethysmographic measures are also being recorded in other studies now under way.

oscillograph. The basic circuitry employed has been discussed by Ellson (1952) and by Davis et al. (1954).

B. Procedure

The procedure involved three main phases. The differences between experiments are specified later in the descriptions of the individual studies.

Phase 1

Preliminary observations had shown that Ss from our population could be highly motivated when the experiments were cast in a detection of deception setting. Therefore, Phase 1 provided a relatively free-choice situation in which S made a decision to "steal" an object from one of three boxes or not to steal, as he wished. This provided the setting for interrogation in Phase 3 later in the experiment.

S entered the experimental room and read instructions placed on a desk. The instructions are given in detail in Appendix C. In essence, they informed him that each of three boxes contained valuable objects. He was to pick up one box and open it. If he chose to do so, he should take the object in the box and put it in his pocket or purse. If not, he should simply replace the lid. In either case, he should return the box to its original position and leave the room. Very few Ss in fact took nothing.

Phase 2

S then returned to the subject room, where he was seated in the armchair, and the second phase of the experiment began. E stated that he would now proceed to discover whether S had in fact taken an object from the box. The various recording electrodes were attached, a simple explanation being given of the function of each. E maintained a carefully formal, but not hostile attitude throughout. When the leads were attached, S was given a second set of written instructions, which differed in certain key aspects for the experimental and the control groups. The instructions are reproduced in Appendix C.

For the experimental Ss, the objective of this phase was to reinforce differentially responses to the concepts "true" and "false". This was accomplished in two ways:

1. Many earlier studies in our laboratory under Contract Nonr 908-15 have shown that a loud tone can serve as an unconditioned stimulus for the arousal of somatic responses. By selecting linguistic stimuli in the form of questions to which answers of obvious truth or falsity could be given, it was possible to reinforce differentially answers in these two categories. For example, it would be extremely improbable that a question like the following could be truthfully answered other than in the affirmative: "Do you occasionally put off things which ought to have been done sooner?". The questions were largely drawn from the Lie Scale of the Minnesota Multiphasic Personality Inventory. For the experimental S in the present setting, the loud tone was always paired with a false answer and never presented when an answer was true. Thus, the presentation and non-presentation of the loud tone was made response contingent: somatic responses were selectively elicited or augmented only when a false answer was given.

2. True answers were also reinforced differentially, the reinforcer being a small monetary reward. Each time experimental Ss gave a true answer a counter on the armchair clicked over five times indicating that S had earned five cents; the total reward accumulated was paid to S at the end of the experiment. No monetary reward was ever given for false answers.

Twenty questions were projected onto the screen in the subject room. The questions and the instructions presented to the experimental Ss are given in Appendices A and C. In order to be certain that some false answers would be given, S was instructed deliberately to falsify his responses on five of the 20 questions, choosing whichever five he wished. These five were paired with the auditory stimulus, while all true answers led to the monetary reward as described earlier.

The control Ss provided data with which to compare the effects of the differential reinforcement of true and false answers for the experimental Ss. The loud tone and the clicks of the counter for monetary reward were presented on the same number of occasions as for the experimental Ss, but in a pattern which was randomized in relation to the control S's responses. These stimuli were, therefore, not contingent upon the type of answers given to the 20 questions. Suitable substitutions were made in the instructions to the control Ss, indicating that the clicks and tones were "...simply programmed into the experiment and should not bother you", so that there was no association at all with positive reinforcement. Otherwise the questions and instructions were identical for both C and E groups. Thus, the procedure to which the control Ss were exposed served to equate them to the experimental Ss in all respects except for the response-contingent nature of the reinforcement.

Phase 3

Immediately following this twenty-minute period of differential reinforcement, a series of test stimuli was presented in a setting perceived by S as the detection of the action he had taken in Phase 1. Instructions were projected onto the screen in the subject room informing S that: the procedure would remain identical with that to which he had just been exposed; he would be required to respond to seven different questions, some of a general nature and others related to his actions in the initial phase; and, there would be no restriction upon whether he gave true or false answers. Each question was presented twice; the questions and their order in each of the two runs are given in Appendix B. Since there was no means by which the truth or falsity of answers to the critical questions relating to actions in the initial phase could be determined immediately after a response was made, the fiction of differential reinforcement was maintained by simply rewarding all truthful answers to the general or buffer questions.

At the end of Phase 3, E made the best decision possible from rapid visual inspection of the records of somatic responses and gave his opinion as to the action S had taken in the initial phase of the experiment. The probability that these decisions would be erroneous could have been decreased significantly with more precise examination of the records, but the timing of the session, which occupied about 50 minutes, did not permit this to be done under the presen circumstances. In any case, the decision itself was not important to the experiment. S returned the object, if one had been taken in the initial phase; he received a payment of $2.00 if E had erred in his decision; and, was paid the amount of money recorded on the counter for truthful answers. The procedure terminated at this point.

C. Measures of Somatic Responses

Six measures were obtained from the three somatic responses recorded. In all instances measurement involved only those portions of the recordings which followed presentation of the stimulus item and occurred prior to the onset of the reinforcement. Thus CRs were not confounded with UCRs to the reinforcers, i.e., the noise or clicks. In a few doubtful instances the particular portion of the recording was not included in the analysis.

Basal Skin Resistance Level (BRL)

BRL was calculated from the GSR recordings by measuring the baseline level at points just prior to the presentation of each stimulus item and converting the measurements to ohms using calibrations made at the time the records were taken.

Galvanic Skin Response (GSR)

The GSR was defined in terms of the parameter: peak decrease in resistance following the presentation of each question. To be counted as a response the onset of the GSR had to occur within five secs. after question onset. Measurements of this parameter were made directly from the GSR recording, using calibrations obtained when the records were taken. GSR was then expressed as a percentage change from baseline (BL).

Galvanic Skin Response Latency (GSRL)

Latencies of the GSR following presentation of the various stimulus items is another parameter of this somatic response which, preliminary studies suggested, might be influenced by the differential reinforcement procedure. GSRL was defined as the time from the stimulus presentation to the peak decrease in resistance of the subsequent GSR as defined above. It was measured to the nearest 0.5 mm. directly from the GSR recordings and then converted to seconds on the basis of the speed of the paper upon which the recordings were made.

Breathing Rate (BR)

BR was determined by measuring the time for five inspiration-expiration cycles prior to presentation of a stimulus item and for five cycles afterwards, subtracting the two, and taking the difference as a percentage of the prestimulus value.

Breathing Amplitude (BA)

Preliminary studies had suggested that, although often highly correlated with breathing rate, BA was another parameter of respiration worthy of consideration within the context of the present experiments. Peak amplitudes were determined for five respiratory cycles prior to and five immediately following presentation of each stimulus item. The difference between the means of the two series, expressed as a percentage of the pre-stimulus mean, was taken as the measure of BA. For both BR and BA, in those recordings where five cycles were not available prior to the onset of reinforcement, as occurred frequently in Phase 2, it was necessary to measure as few as three cycles.

Heart Rate (HR)

Heart rate was determined by ignoring the beat immediately following question onset, then considering the next six QRS peaks: the distance in mm. from peak 1 to peak 6 was subtracted from an identical measure for the six peaks preceding the question. Differences were expressed as a percentage of this pre-question rate. For the three experiments described in the present report the electrocardiogram was recorded only during Phase 3, the detection phase.

IV EXPERIMENT I

TRANSFER EFFECTS OF DIFFERENTIAL REINFORCEMENT

Experiment I was designed as a study of transfer effects of the differential reinforcement of true and false responses, a test of the general position discussed in the introduction to this report. The research design consisted of the three phases and followed the procedure described in the preceding section. All Ss were drawn from the general population of undergraduate students at Indiana University, 19 Ss in the Control Group and 16 in the Experimental Group.

RESULTS

In presenting the results of Experiment I, analyses of data collected during Phases 2 and 3 of the research design are treated separately. Certain key trends are described graphically and summaries of statistical tests are given in tables. The one-tailed form of student's t was used to test for statistical significance, "significance" being defined in terms of the conventional .05 level of confidence.

A. Effects of differential reinforcement

As described earlier, Phase 2 was a period during which the treatments of the C and E Groups differed only in the fact that reinforcement of FAs* was random for the former and response contingent for the latter. The analysis which follows is directed toward specifying the effects which this difference had upon the various measures of somatic responses recorded. If the predicted effects of the differential reinforcement had in fact occurred, measures of somatic variables during Phase 2 should have shown the following characteristics:

1. There should have been no significant differences between the C and E Groups at the beginning of the differential treatments;

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*A false answer (FA) was defined as one not agreeing with the answer specified in Appendix A, while a true answer (TA) was one which did so agree.

2. The between-group differences in somatic responses accompanying FAs should have become progressively greater as a result of the repeated differential reinforcement.

Initial Comparability of C and E Groups

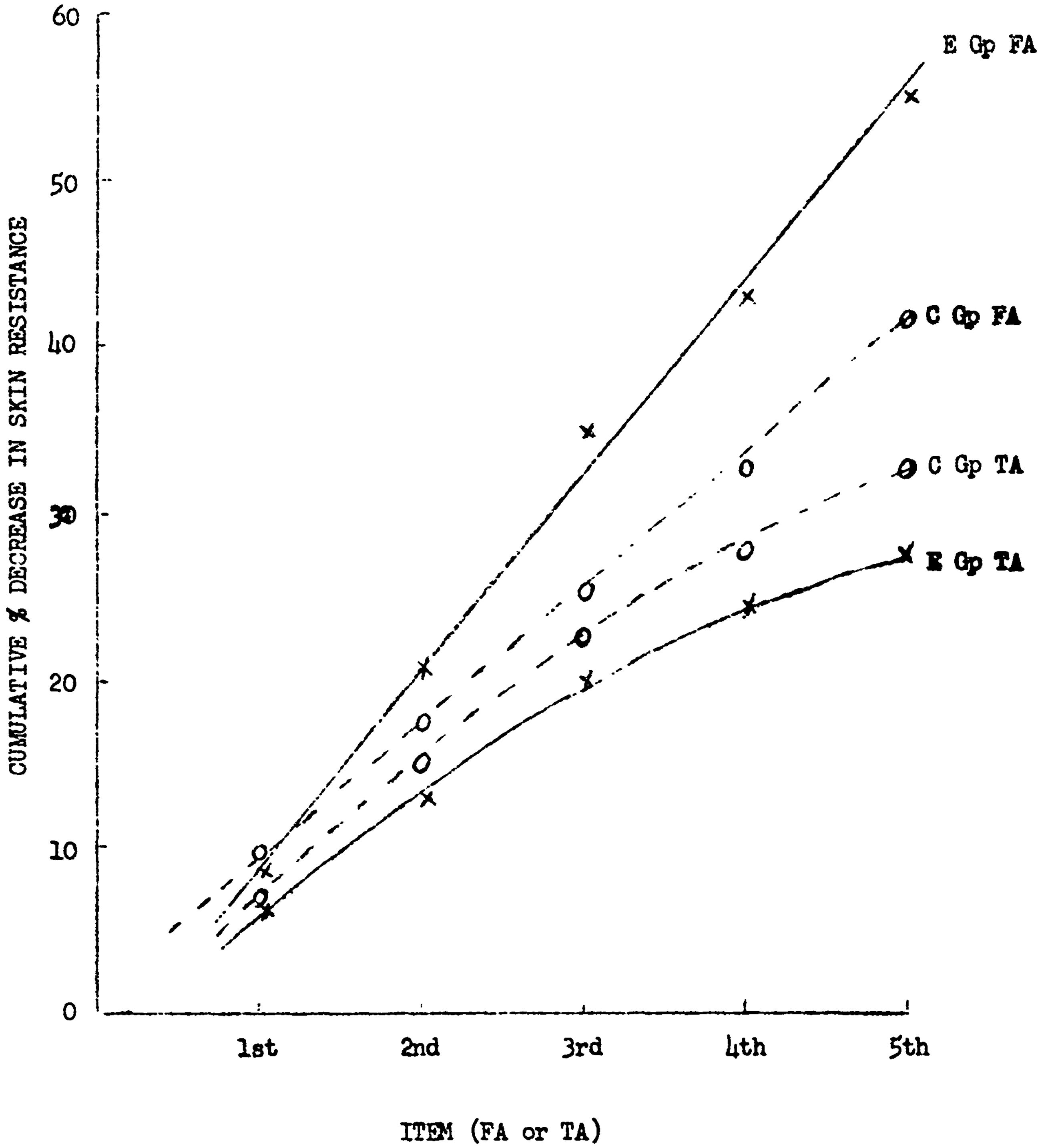
Since Ss were assigned randomly to the C and E Groups, it would be expected that there would be no significant differences between groups at the beginning of Phase 2 and that any later differences could be attributed to the experimental treatment. Fig. 1 shows graphically the cummulative effects of the differential reinforcement of FAs and TAs in the two groups for GSR. The abscissa represents, in ordinal sequence, the five stimulus items on which false or true answers were given. Curves were fitted by inspection. Table 1 shows t tests between the FA and TA coordinates at the beginning and end of acquisition for each group for each measure. For GSR it can be seen that Experimental group differences between TAs and FAs become significant by the last trial. Although differences also become significant in the Control Group ($p < .05$) the differences in the Experimental group were greater ($p < .001$). Only one other t is significant in Table 1, although values do generally increase over the five acquisition trials. Galvanic skin responses accompanying TAs behaved quite differently from those accompanying FAs.

TABLE 1

Experiment I: Phase II: t tests for differences between TAs and FAs during acquisition of response differentiation

Measure	Experimental Group		Control Group	
	first item	fifth item	first item	fifth item
GSR	1.28 NS	4.50 $p < .001$	1.10 NS	1.93 $p < .05$
BR	0.67 NS	0.99 NS	0.67 NS	0.31 NS
BA	0.80 NS	1.20 NS	0.57 NS	1.78 $p < .05$

Fig. 1. Exp. I: CUMULATIVE PLOT OF EXPERIMENTAL AND CONTROL ACQUISITION DATA : GSR.



The general trend (Fig. 1) was for the response size to decrease in both groups as the number of stimulus items increased. Regarding between-group comparisons on FA response size, there were no significant differences. However, even an identical FA response size for the two groups is not incompatible with the presence of conditioning in the E group, since the major criterion for conditioning in this study is a difference in TA/FA response size rather than any difference in FA response size <u>per se</u>. The criterion of greater TA:FA differentiation in the E group is met in the case of the GSR. Moreover, the possibility that this is an instructions rather than a treatment effect can be considered unlikely, since response differentiation in Fig. 1 shows a progressive increase over trials, and the amount of increase is greater in the E than in the C group. Classical conditioning therefore occurs in the GSR. In the only other data recorded during acquisition, breathing amplitude (BA) and rate (BR), no conditioning can be said to occur.

B. Transfer Effects

Phase 3 was designed as a series of test trials to determine the transfer effects of the differential reinforcement procedure of Phase 2 in a situation involving detection of deception. The various measures of somatic responses were analyzed separately for each of the three types of stimulus items used during the test trials:

1. The <u>C-question</u>, which was "critical" in the sense that it referred to the object which <u>S</u> saw and may have taken from one of the boxes during Phase 1 of the experiment;
2. Two <u>NC-questions</u>, which referred to objects contained in the other two boxes but were "non-critical" since <u>S</u> would not have seen or taken them; and,

3. Four neutral or buffer items of the kind used in Phase 2.

Which of the three non-buffer items was in fact the C-question became known to E for certain only at the end of the experiment when S reported upon his action in Phase 1.

In the analyses to follow, data are presented in the form of histograms with three pairs of comparisons representing the mean magnitudes of the measures of somatic responses for C and E groups on the three types of stimulus items.

Evidence for the presence of transfer effects could come from three different kinds of analyses involving between- and within-group comparisons.

Our prediction was that the effects of differential reinforcement of FAs in the E Group during Phase 2 would transfer to false responses during Phase 3, where FAs would be expected to the C-questions and TAs to the NC- and buffer items. If the prediction were correct, the magnitudes of the E Group's responses to the C-questions should be greater than the magnitudes of the C Group's responses to the same type of item. However Table 2 shows that only for GSR were there any significant between-group differences on the Critical question.

TABLE 2

Experiment I: Significances of Differences between Groups on Test Trials

Measure	Question Critical		Non-Critical		Buffer	
BRL	1.34	NS	1.41	NS	5.36	$p < .005$
GSR	2.05	$p < .025$	0.82	NS	0.81	NS
GSRL	1.10	NS	0.70	NS	0.62	NS
BR	0.46	NS	0.02	NS	2.24	$p < .025$
BA	0.56	NS	2.62	$p < .01$	4.04	$p < .005$
HR	1.59	NS	0.04	NS	0.21	NS

Since, again for GSR, both groups give statistically the same response size for NC and Buffer items, this suggests that little response generalization occurs in the E Group. It also suggests that the TA reinforcement contingency is itself of small effect since C and E groups were differentiated also on the basis of TA reinforcement (contingent or random counter clicks) but no differentiation appears in the TAs to the NC or Buffer questions.

Further evidence for transfer effects from the differential treatments in Phase 2 to responses in Phase 3 should come from within-group comparisons. It would be expected that, for the E Group, the response-contingent reinforcement of FAs would transfer in such a way that somatic responses to C-questions in Phase 3, associated as they were with FAs, would be affected to a greater extent than responses to NC- and buffer items. Table 3 summarizes the significances of differences between the E and C Groups for the derived measure: responses to C- minus responses to NC-items. This measure has the advantage of focusing more precisely than any other single measure upon the difference in treatments of the two groups during Phase 2: through a simultaneous consideration of the two kinds of responses (to FAs and to TAs). For this and other reasons detailed in discussing the results of Phase I, the difference measure is regarded as the most powerful measure of the three and will be relied upon most heavily.

TABLE 3

Experiment I: Significances of Differences between Groups for the Derived Measure (Response to Critical minus Response to Non Critical Questions).

Measure	t	
BRL	0.02	NS
GSR	1.76	$p < .05$
GSRL	0.28	NS
BR	0.16	NS
BA	3.85	$p < .005$
HR	1.78	$p < .05$

Significant between-groups differences were obtained on this difference score for three of the somatic measures: GSR, HR and BA. For BA however, although differences are highly significant (Table 2) they are in the reverse direction from that predicted, Group E being superior to Group C. Since in these first studies HR was not recorded during Phase II it cannot be known whether a conditioned response was acquired. It seems clear however for GSR that following acquisition of conditioned response differentiation in Phase II (Fig. 1 and Table 1) this response differentiation generalizes to test phase items specifically concerned with the mock theft.

C. Detection of deception

The experiment concluded with a "best guess" based on quick visual inspection by E about the nature of each S's action during Phase 1, when S saw and may have taken an object from one of the three boxes. Following completion of the experiments the recordings of each S's somatic responses to the different types of questions in Phase 3 were analyzed in detail. The results of the analysis were described in the preceding section. Although the emphasis then was upon transfer effects, the data presented in the following figures and tables provide information relevant to differential somatic responses to the three types of questions, the information upon which detection depends. It is clear that not all the somatic responses were effective in discriminating between the different types of items. For example, the BRL measure (Fig. 2) showed quite large, but non-significant differences between groups for all items; but the magnitudes of responses within groups were very similar, thus making this measure, by itself, of no value in detection. Within group differences did appear in all other somatic measures taken. Their relative contributions to detection are shown graphically in Fig. 8. Information about somatic measures (other than BRL) is included in the histogram, the vertical axis labelled "percentage detected" representing percentages of trials during which the responses to C-questions were greater than responses to NC-questions. The heights of the columns indicate the means for each somatic measure; separate columns make it possible to compare C and E Groups. Since each S's contribution to each mean is derived from responses to one C- and two NC-items on each run, the probability of the response to the C item exceeding both of the responses to the two NC items is 33 1/3%. Three features of Fig. 8 are of particular interest in the present context:

1. For all measures other than breathing rate, detection, as defined above, was superior within the E Group.

2. In all instances detection within the E Group was better than chance This was also the case within the C Group, with the exception of heart rate which approximated chance level.

3. There were obvious differences among the various somatic measures in the extent to which they exceeded chance. The possibility of maximizing detection by some weighted combination of these deserves consideration.

Fig. 2. Exp. I. BRL OF THE TWO GROUPS AT DIFFERENT STAGES DURING PHASE 3.

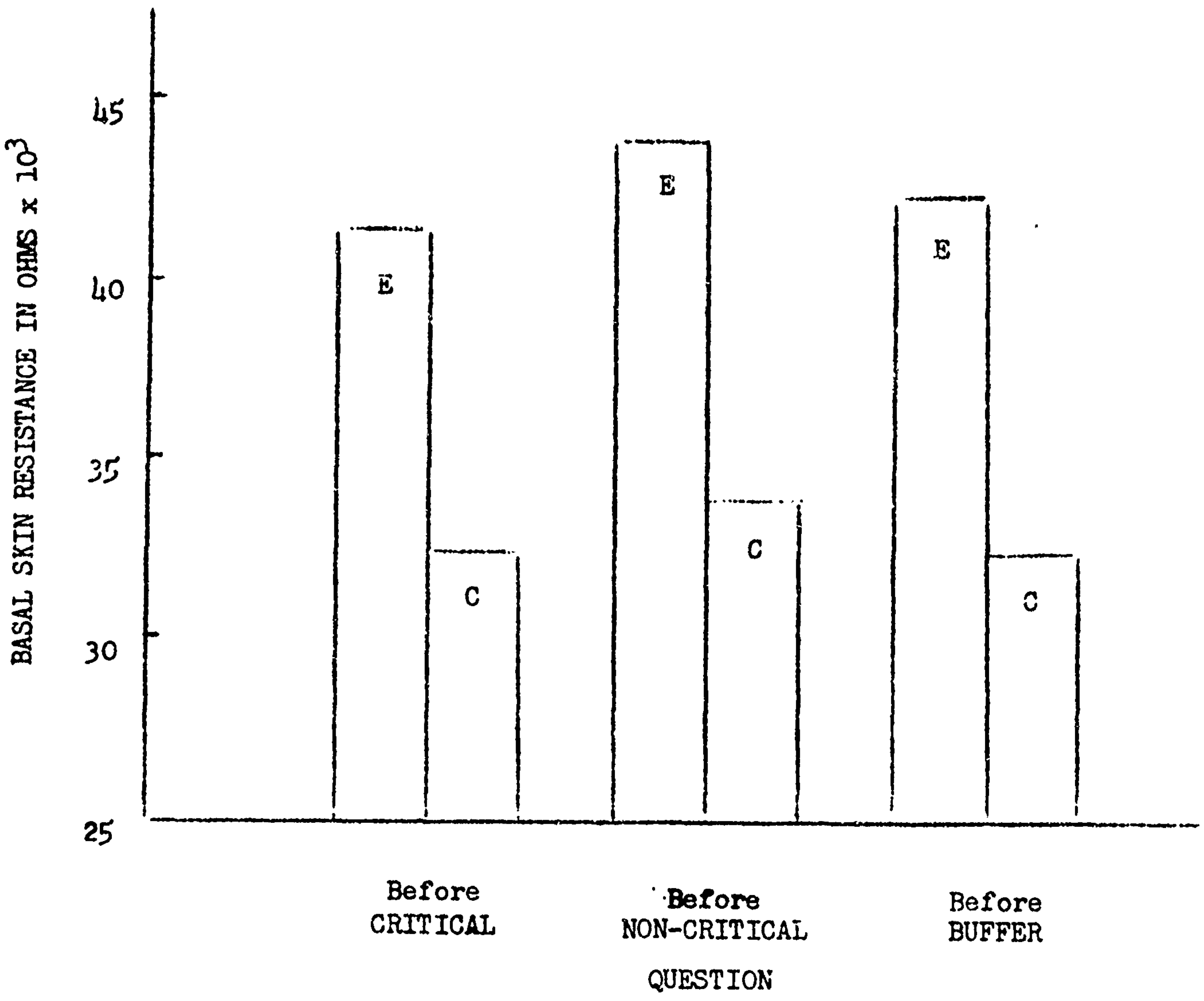


Fig. 3. Exp. I. GSR TEST PHASE - AMOUNT OF RESPONSE GIVEN ON EACH QUESTION-TYPE FOR THE TWO GROUPS E AND C.

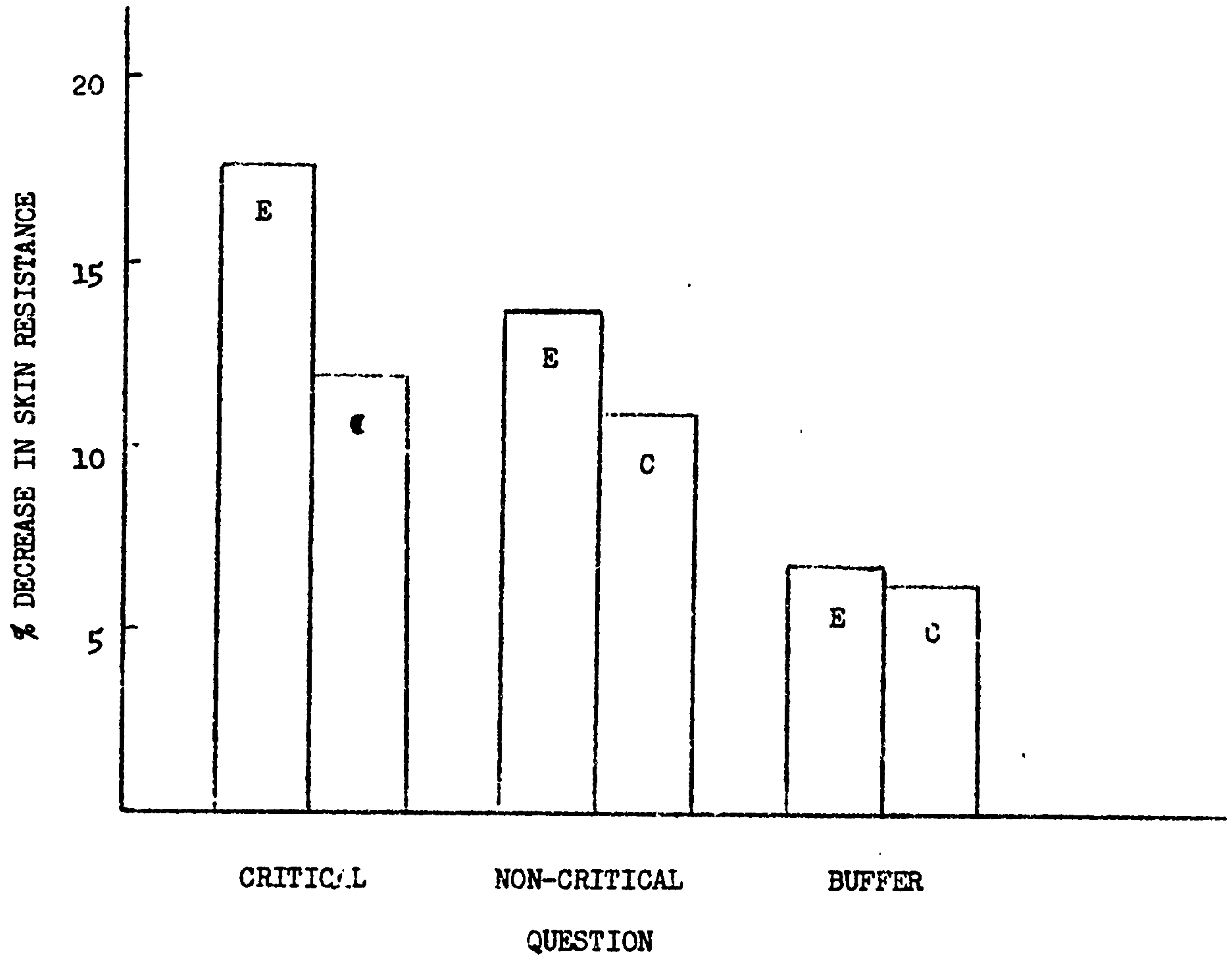


Fig. 4. Exp. I. GSR LATENCY TEST PHASE - BETWEEN-QUESTION DIFFERENTIATION SHOWN BY THE TWO GROUPS E AND C.

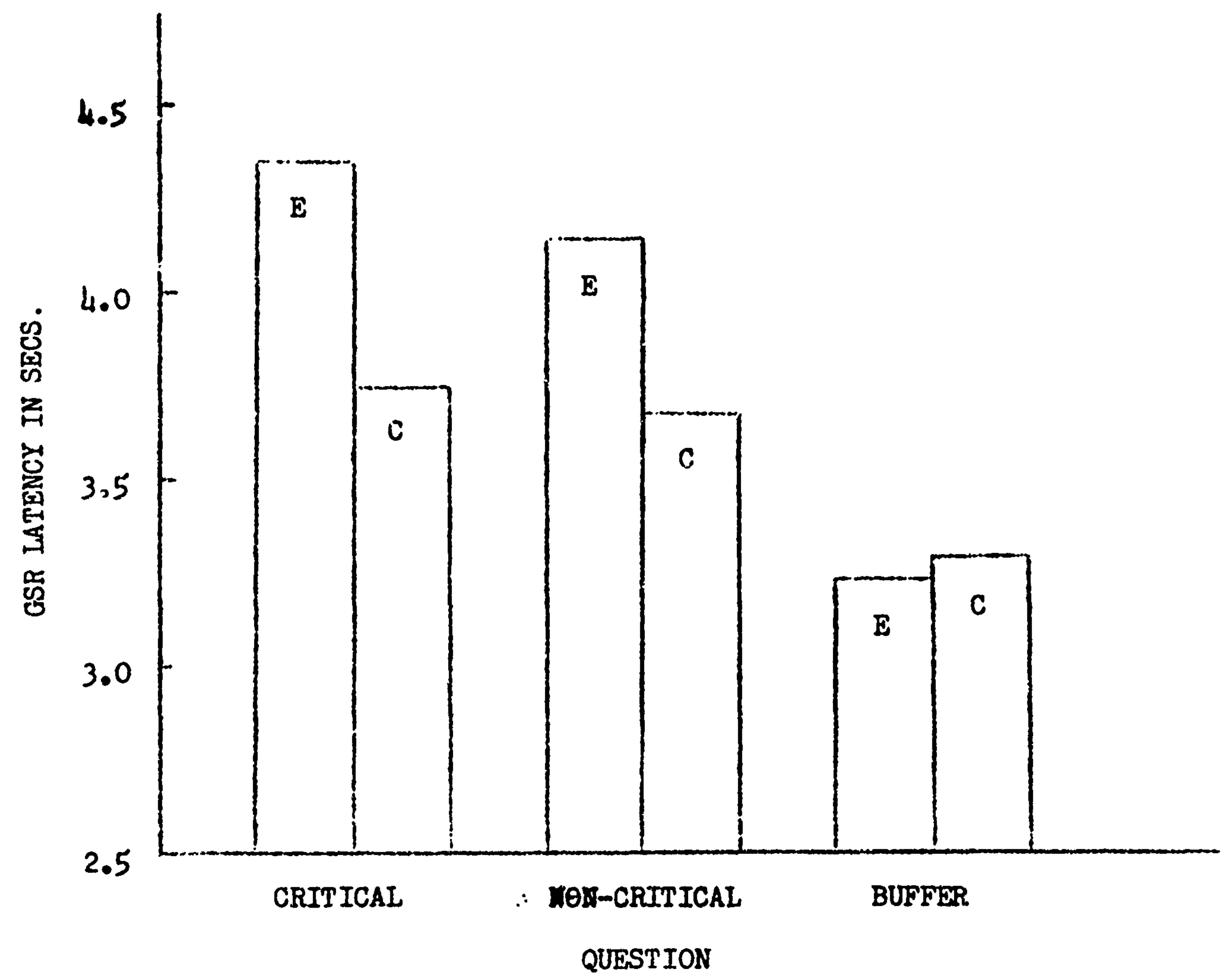


Fig. 5. Exp. I. HEART RATE TEST PHASE - BETWEEN-QUESTION DIFFERENTIATION SHOWN BY THE E GROUP AND C GROUP RESPECTIVELY.

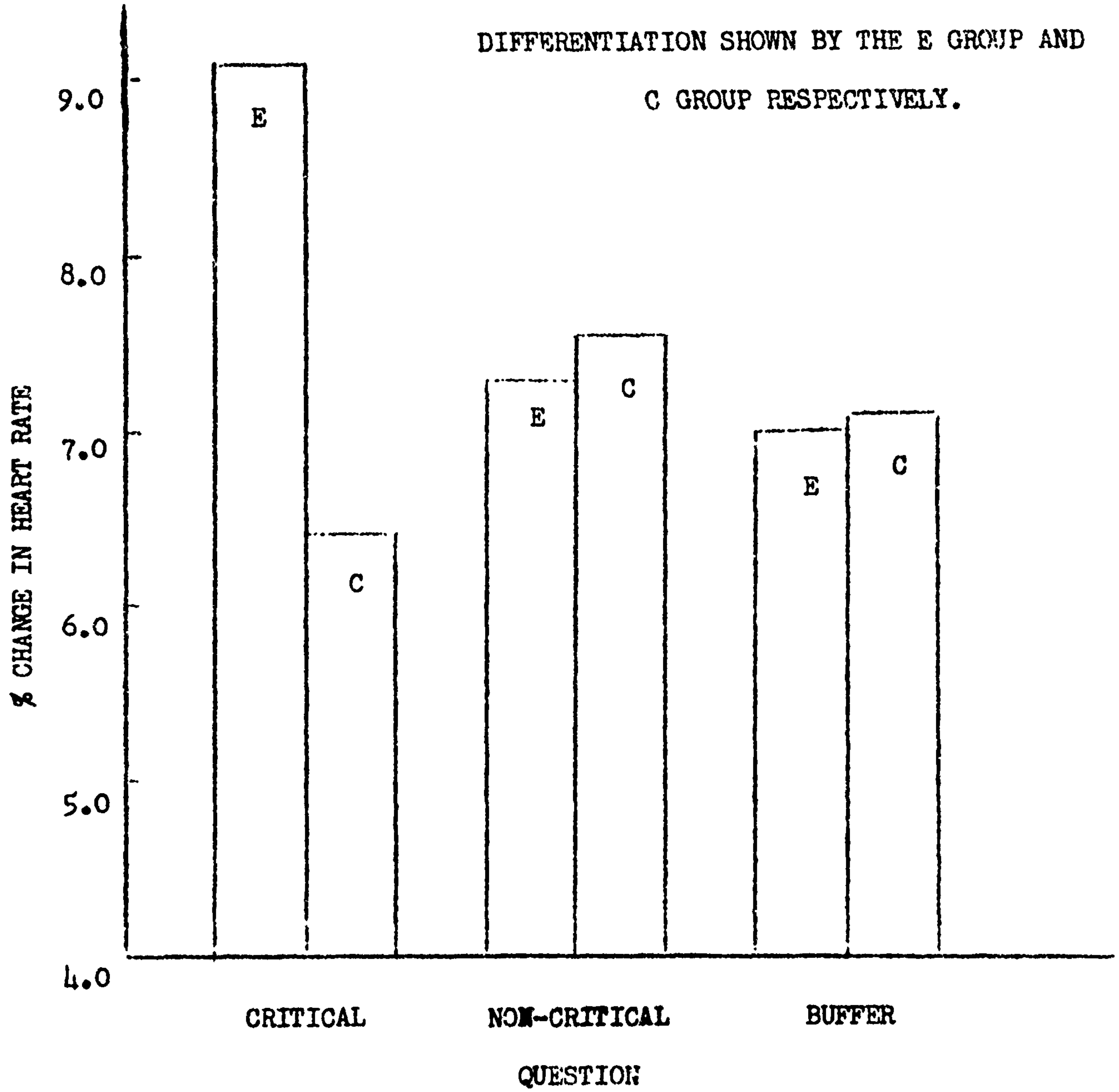


Fig. 6. Exp. I BREATHING AMPLITUDE TEST PHASE

BETWEEN-QUESTION DIFFERENTIATION SHOWN BY E AND C GROUPS RESPECTIVELY

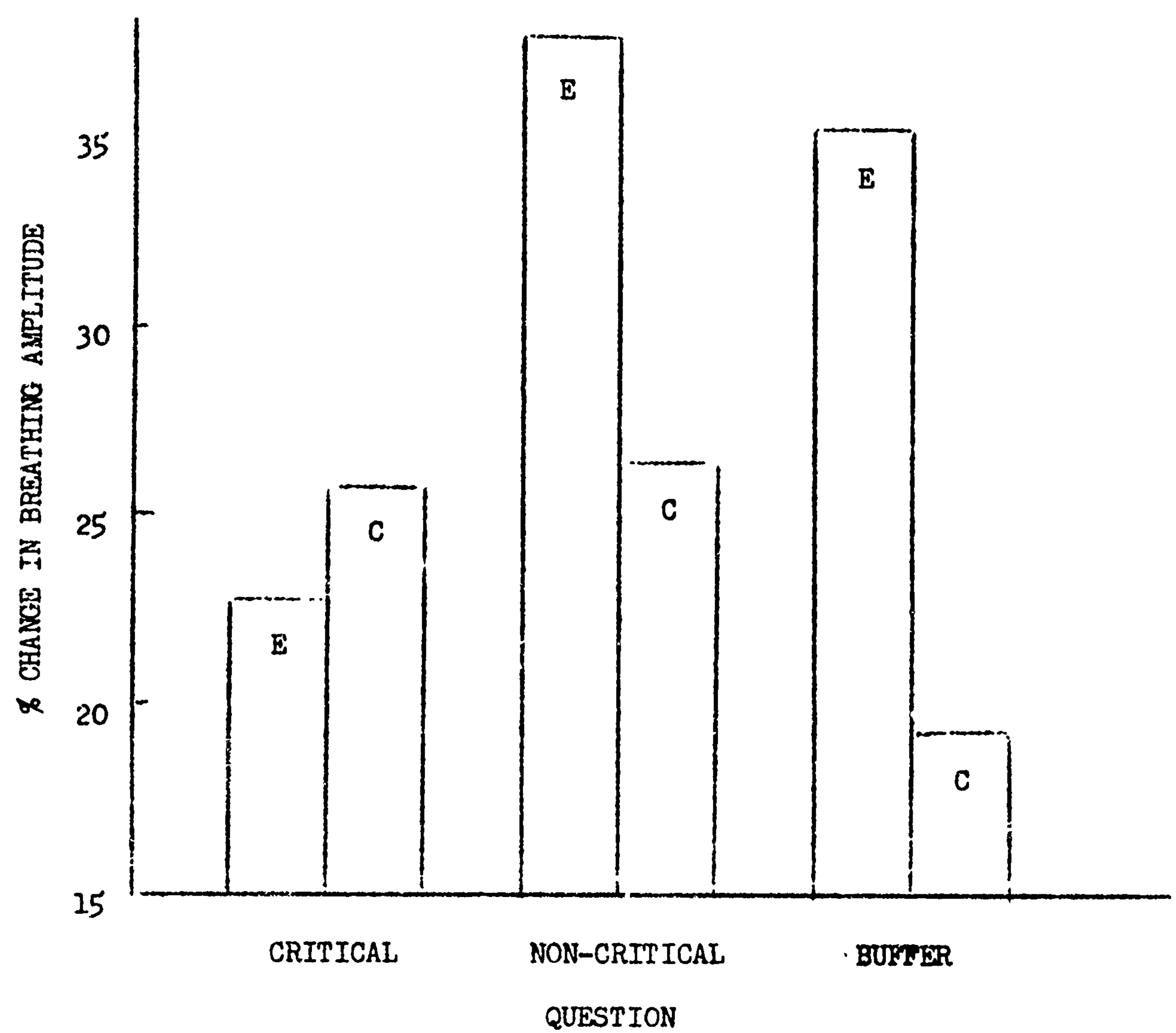
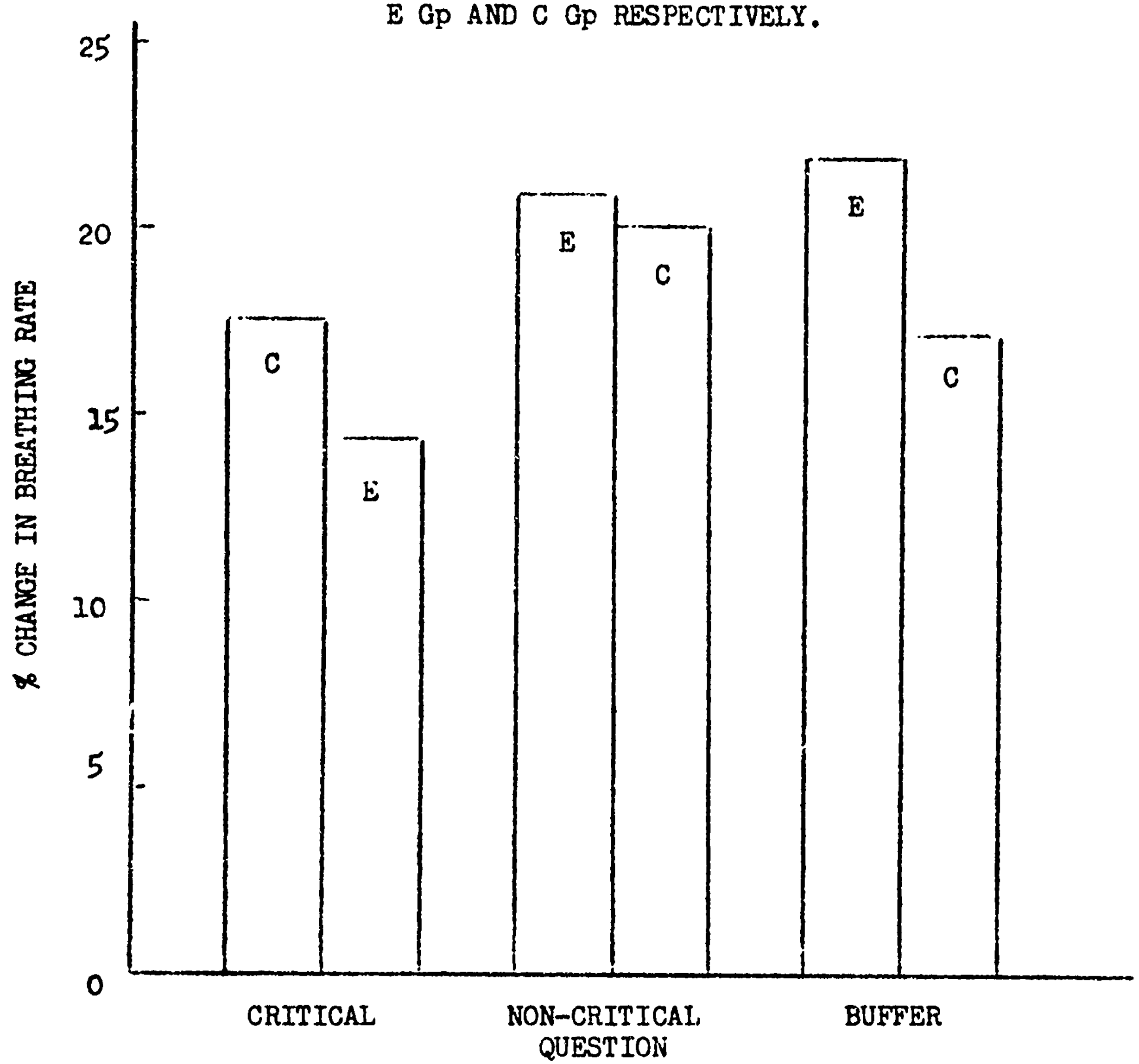


Fig. 7. Exp. I. BREATHING RATE TEST PHASE BETWEEN-QUESTION DIFFERENTIATION SHOWN BY THE E Gp AND C Gp RESPECTIVELY.



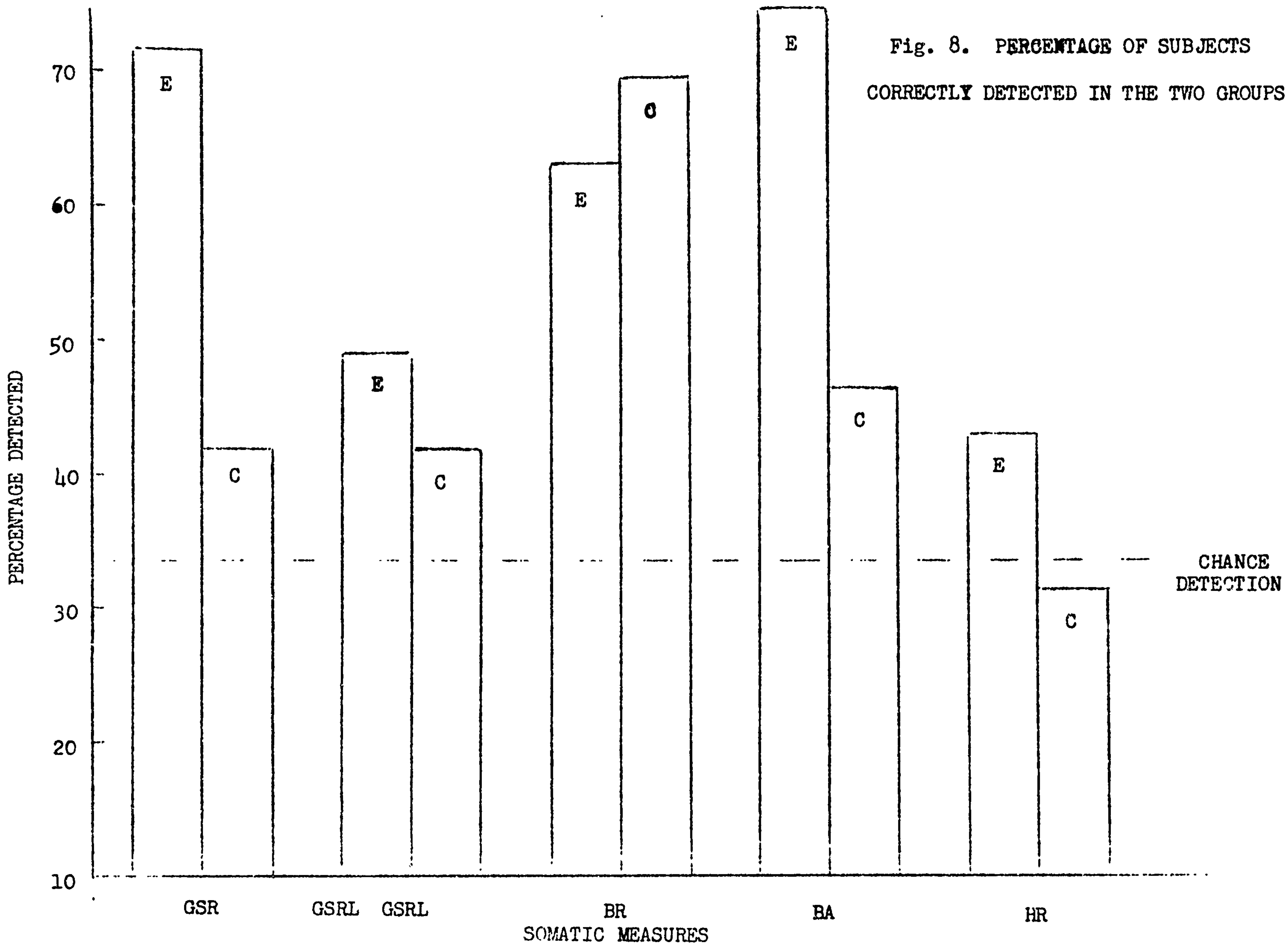


Fig. 8. PERCENTAGE OF SUBJECTS CORRECTLY DETECTED IN THE TWO GROUPS

V. EXPERIMENT II

ATTEMPTS TO INTERFERE WITH DIFFERENTIALLY REINFORCED RESPONSES DURING TESTS FOR TRANSFER EFFECTS

Experiment I showed that the magnitude of a semantically conditioned response, once established, can be affected by differential reinforcement and that such treatment can carry over, as transfer effects, to a subsequent situation in which the special reinforcement is not present. In the introduction to this report we pointed out that such conditioned responses might be altered by new conditioning, interfered with or suppressed by competing S-R units, and extinguished by repeated presentation of the conditioned stimulus without reinforcement. Under our experimental conditions, the first and third of these factors can be controlled or their effects measured. However, the second could introduce problems, particularly if S were deliberately to attempt to engage in confusional tactics. The same problems could arise in situations where the procedures were being applied for practical, rather than experimental purposes. Experiment II was designed to gain some idea of the effects of certain of the most obvious confusional tactics upon somatic responses when detection was preceded by a period of differential reinforcement of the kind used in Experiment I.

The design required study of a new E Group receiving the identical treatments afforded experimental Ss in the first experiment, but who employed confusional tactics during the Phase 3 detection period. Eighteen Ss, from the same general population as those in Experiment I, comprised the new group. The procedure to which they were exposed deviated from that for the E Group in the first experiment only in Phase 3, the detection phase. Immediately before this phase began, each S was given special instructions describing certain tactics which he was to use in doing his "best to mislead us". The instructions are given in Appendix C. Two types of confusional tactics were suggested, tactics which Kubis (1962) has reported as lowering the accuracy of detection in the present type of laboratory situation from about 80 per cent to as low as 20 per cent. One involved the voluntary control of muscle tension and breathing, which can produce effects upon the somatic variables being recorded; the second made use of stimuli, which had previously been conditioned, to arouse competing somatic responses, i.e., memory images of situations which had produced emotional responses in the past. The instructions coached each S in the use of both these tactics.

RESULTS

The results of Experiment II are presented in two short sections: the first summarizes evidence for the fact that, as in Experiment I, differential reinforcement during Phase 2 produced differences in somatic responses on the FA and TA trials; the second examines the data for effects of the use of confusional tactics. Tests for significances of differences used the same definition and statistic as Experiment I.

A. Effects of differential reinforcement

Since the sample of Ss in the present experiment was drawn from the same general population as those in the first experiment and was subjected to the same Phase 2 treatment as the E Group in that study, comparisons may be made between groups in Experiments I and II. Table 4 summarizes the significances

TABLE 4

Within-Group Comparisons of Somatic Responses on FA and TA Trials

Measure	Experimental Group (Exp II)				Control Group (Exp I)			
	first item		last item		first item		last item	
GSR	1.23	NS	2.67	$p<.01$	1.10	NS	1.93	$p<.05$
BR	0.54	NS	0.27	NS	0.67	NS	0.31	NS
BA	1.00	NS	0.09	NS	0.57	NS	1.78	$p<.05$

of differences between the present E Group and the C Group of the first experiment at both the beginning and the end of the differential reinforcement procedure. The results indicate that the two groups were comparable initially, but that greater change between them had developed in GSR by the end of this differential reinforcement period. The effects for breathing measures were non-significant.

B. Effects of confusional tactics

Table 5 shows that under these conditions, transfer of response differentiation is only significant for GSR, the notable case of non-significant transfer being HR, where the overall data can only be regarded as suggestive. GSR does show significant differentiation (that is, between C and NC items) within the Experimental group (Table 5) while no other measure does. We should note however that the amount of this differentiation was not significantly different for any measure from the amount shown by the C Group of Experiment I.

TABLE 5

Experiment II: Significances of Within-Group Differences on Test Trials

Measure	Experimental Group		
	C vs NC	C vs B	NC vs B
GSR	1.69 $p < .05$	2.67 $p < .01$	1.94 $p < .05$
GSRL	0.02 NS	0.36 NS	0.28 NS
BR	0.23 NS	0.31 NS	0.02 NS
BA	0.16 NS	0.44 NS	0.36 NS
HR	1.46 NS	3.11 $p < .005$	2.01 $p < .05$

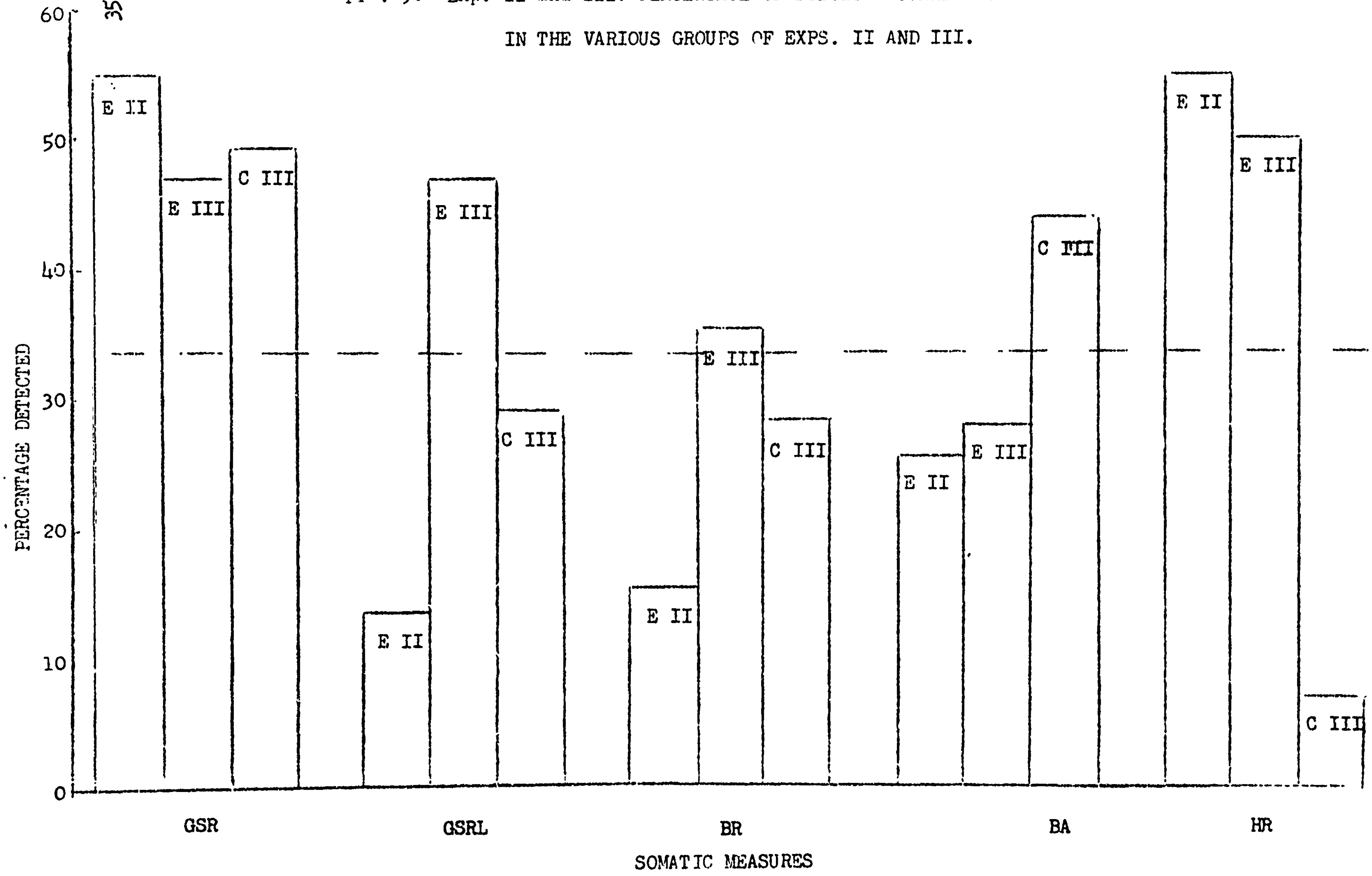
As in Experiment I, detection of deception was attempted, first, on the basis of a rapid inspection of the recordings of somatic responses while S was still present and second, on the basis of a detailed analysis of the records carried out after the experiment was completed.

The results of the detailed analysis are presented in Figure 9. The columns labelled "E II" represent the percentages of trials during which the somatic responses to C-questions were greater than responses to NC-questions, i.e. the percentage of occasions on which the object taken was correctly specified. The heights of the columns indicate the means for each somatic measure; the probability of responses to C-items exceeding those to NC-items was 33 1/3% Two major features of the results are of special interest, particularly when compared with results of Experiment I shown in Figure 8: Note that the measure BRL, has been omitted from both histograms since logically it cannot yield response differentiation, being measured before the question is actually asked.

In the present study only two somatic measures, GSR and HR, remained above the chance level; this level, under the conditions of Experiment I, was surpassed by all five measures in the corresponding E Group.

Of these two measures, GSR decreased in percentage successfully detected by 16.5%, while HR actually increased by 12.0%.

Fig. 9. Exp. II and III. PERCENTAGE OF SUBJECTS CORRECTLY DETECTED IN THE VARIOUS GROUPS OF EXPS. II AND III.



VI. EXPERIMENT III

THE ROLE OF THE UNCONDITIONED STIMULUS IN THE DIFFERENTIAL REINFORCEMENT PROCEDURE

In discussing the general method used in the present series of studies we referred to earlier research in our laboratory under Contract Nonr 908-15 which had shown that a loud tone can serve as an unconditioned stimulus for the arousal of somatic responses. We therefore used a loud tone as reinforcement during FA trials in Phase 2 of the experiments discussed so far; TAs were never reinforced by this UCS, but were instrumental to S receiving a small monetary reward. In discussing results of the previous two studies we have assumed that the loud noise did indeed function as a conventional UCS, eliciting somatic responses in some more or less direct manner. However, it is also possible that the noise may have produced its end effects in another way: it may have served as a cue for S, indicating E's awareness that S had falsified his answer. "Being caught in the act" might have served as a conditional stimulus for changes in somatic variables.

Since our earlier studies had shown that tones of low intensity do not act as an adequate UCS for eliciting somatic responses, it was possible to design an experiment to study the role of the auditory stimulus as a cue rather than a UCS during the differential reinforcement phase of the procedure and still maintain the major features of the procedure as a whole.

In Experiment III the signal generator was adjusted to lower the loudness of the stimulus tone from 115 db. to a just audible level for each S, while maintaining the frequency at 500cps. In all other regards the procedure described in Experiment I was employed. Thirty-one Ss were obtained from the same general population as in the previous studies, 17 being randomly assigned to an E Group and 14 to a C Group.

RESULTS

If the cue-value of the auditory stimulus were the important factor in the differential reinforcement procedure, it would be expected that the differences between the C and E Groups in the present experiment would be of the same order as those in Experiment I. On the other hand, if the stimulus played the role because of its property of directly evoking somatic responses, then no significant differences should appear between the present two groups. The results described below support the latter position.

A. Phase 2. Effects of differential reinforcement

The information in Table 6, which summarizes the significances of differences in somatic responses at the beginning and end of Phase 2, indicates that the two groups were comparable initially. After exposure to the differential reinforcement the E Group shows no evidence for response differentiation, but oddly, the C Group does show this, for the GSR measure. This analysis is again based upon differences between somatic responses on each FA trial and on the preceding TA trial. These within-group comparisons provide evidence for the failure of the present differential reinforcement procedure to produce significant effects during Phase 2. Differences did not increase with increasing number of trials, as would be expected if the differential reinforcement procedure produced systematic effects.

TABLE 6

Experiment III: Within-Group Comparisons of Somatic Responses on TA and FA Trials

Measure	Experimental Group		Control Group	
	first	last	first	last
GSR	1.23 NS	0.58 NS	1.51 NS	2.44 $<$ p .025
BR	1.34 NS	0.18 NS	1.46 NS	1.42 NS
BA	0.24 NS	1.00 NS	0.32 NS	0.14 NS

B. Phase 3. Transfer effects

Analyses of measures taken during the Phase 3 test trials provided information about any differences between the groups in transfer effects resulting from the Phase 2 treatments. The fact that these treatments were not associated with differential responding in Phase 2 would lead to the prediction that no significant differences would be found in Phase 3.

Within-group comparisons of somatic responses to C questions vs. responses to NC- and buffer questions are summarized in Table 7. No differences are significant other than a maintained response differentiation in the C Group for GSR.

TABLE 7

Within-Group Comparisons for Discrimination of Critical from Non-Critical Questions on Each Response Measure

Measure	Experimental Group		Control Group	
	C vs.	NC	C vs.	NC
GSR	1.26	NS	1.94	$p<.05$
GSRL	0.52	NS	0.28	NS
BR	0.14	NS	1.34	NS
BA	0.33	NS	1.53	NS
HR	0.57	NS	0.38	NS

Between-group comparisons were made in terms of the derived measure, somatic responses to C-, minus responses to NC-items, and are presented in Table 8.

TABLE 8

Experiment III: Significances of Differences Between Groups for the Derived Measure, Response to Critical minus Responses to Non Critical Questions

Measure	t	
GSR	1.13	NS
GSRL	0.08	NS
BR	0.67	NS
BA	1.24	NS
HR	1.23	NS

Detection of Deception

A more detailed analysis of the kind described in Experiments I and II above gave the results summarized in Figure 9 in the columns labelled "E III" for the experimental Ss and "C III" for the controls. Tests, using the t statistic, show none of the differences to be significant.

VII GENERAL DISCUSSION

The assumption that somatic responses, such as the galvanic skin response, heart rate and respiration, react differentially to true and false statements during interrogation has long been basic to techniques used in the detection of deception. Although the evidence has been interpreted by many as supporting this assumption, questions have often been raised about its validity or about the reliability and accuracy of traditional techniques in measuring the differential reactions. Questions have also been directed at the need for some psychological model in terms of which the differential reactions could be related to broader aspects of human behavior. During the course of earlier studies in our laboratory under Contract Nonr 908-15 it had become clear that certain results could be interpreted in terms of the conditioning of somatic responses to words or other linguistic stimuli. The possibility that such conditioning may generalize beyond relations between specific stimuli and specific somatic responses is suggested in the research literature on semantic conditioning, i.e., generalization to groups of stimuli having similar "meaning". The present report describes three experiments designed to test certain deductions from the possibility in the general context of detection of deception where semantic generalization is assumed to occur within the general concepts of "true" and "false".

In the experiments we have not attempted to condition somatic responses to these concepts. Our <u>S</u>s entered the experiments with the conditioned responses already established. Curves for the Control Group in Figure 1 to 5 show that somatic responses on trials when false statements were made differed from those associated with true statements and that the trends in responding under the two conditions differed as the number of trials increased, responses to true statements tending to decrease as trials increased and those to false statements remaining constant over trials. Presumably these differential responses had been acquired, through the processes of conditioning, earlier in each S's developmental history. General culture patterns of the society to which Ss belonged would have rewarded truthful statements; false statements would have been associated with some kind of punishment. The possibility that differential reinforcement might increase the differences in somatic responses to true and false statements and that the effects might carry over when the reinforcements were no longer present led to the first of the three experiments The other experiments were designed to study two major features of the procedure, both of which might exert significant influences on its effectiveness.

A. Methodological issues

Before discussing the experimental results there are certain methodological issues which deserve special attention.

There were several reasons for selecting the three somatic responses recorded in the present experiments: the electrocardiogram, galvanic skin response, and respiration. They have been chosen by other investigators as objective indicators of conditioning and of generalization or transfer in studies of semantic conditioning. We have had a very considerable amount of experience in studying them experimentally over a number of years. Pilot studies by the senior author in preparation for the present research series had suggested that they would serve our purposes well. These particular somatic responses are those most frequently used in the practical procedures of interrogation. The results of the present experiments suggest that other responses should also be examined for the possibility that they may be more sensitive to the differential reinforcement procedure and less affected by confusional tactics. We are now working with plethysmographic, electromyographic and electrogastrographic responses, all of which we have studied in other contexts.

Our present results also suggest the need to consider other specific measures of the somatic responses once they are recorded. The measures used in the studies described in this report do not exhaust the possible array for any one of the responses. There are other parameters to be measured and other derived indices to be calculated, which might reflect the effects of differential reinforcement more clearly than at least some of those measures used in the present experiments and thus increase the accuracy of detection. We are already investigating some of the possibilities.

Of basic importance to the differential reinforcement procedure and, consequently, to the study of transfer effects and detection is the efficiency of the unconditioned stimulus in eliciting and reinforcing somatic responses. Our previous research on the stimulus control of somatic responses led us to select a loud tone, 500 cps. at 115 db. for 4 sec., as the UCS in the present experiments. In general results show that the tone served its role adequately. However, the results of Experiment III, which demonstrated the importance of the property of the tone to evoke somatic responses when compared with its property as a sensory cue, suggest that other UCSs should be studied in order to discover whether some other stimulus may be more effective in the differential reinforcement procedure. Experiments are presently underway to study the relative effectiveness of electric shock as a UCS.

In designing the procedure used in the experiments described in this report we decided to reinforce true as well as false statements, using a small monetary reward for the former. The reasoning was that this could result in a greater differentiation of somatic responses on TA and FA trials than the reinforcement of false statements only. This hypothesis needs testing; however a variety of evidence, particularly the similarity of E and C Groups responses on TAs suggests that the positive plays a minimal role. In addition it introduces complications into interpreting data and has therefore been dropped from subsequent experiments.

Recently Feather (1965) has criticized "... the frequent absence of information concerning essential elements of design and procedure... in studies of semantic generalization, giving particular attention to two major kinds of controls." Although our present experiments were concerned with responses which had already been to some extent conditioned, these controls are still important to any conclusions we may draw about effects of differentially reinforcing the responses and about transfer effects during the subsequent detection period. Both had already been incorporated in our research design. The first type of control centers upon the necessity to demonstrate that "... an increment in response to a CS during or after acquisition trials is related to the pairings of a CS with a UCS, and not to a more general change in responsiveness to all stimulation" (Feather, 1965). The C Groups in our experiments provided the basis for meeting this requirement. For *S*s in these groups the *UCS*, loud tone, was received on the same number of trials as for the E Groups, but the tone was not paired with false responses as it was for the E Groups; rather, it appeared randomly among the 20 trials of the differential reinforcement period. If general changes in somatic responses occurred merely as sensitization to the auditory stimulus *per se*, responses of the C Group should not have differed from those of the E Group either during Phase 2 or Phase 3 of the experiments. This control adds considerable strength to the conclusion that the differences between the groups can be attributed to the effects of the differential reinforcement procedure.

Feather's second essential control "... pertains to differentiating extinction effects from generalization effects." Our experiments had been designed to provide a means for studying the possible contributions of the two effects by presenting the generalization stimuli, C- and NC-questions, in the middle of each run during Phase 3, between buffer items, and by counterbalancing the order of their presentation during the two runs. It would be expected that any generalization or transfer of the differential reinforcement during Phase 2 would appear as differences between somatic responses to C- and NC-items on the one hand and to the buffer questions on the other; extinction effects should appear as progressive changes in responses to questions as the number of non-reinforced trials increased during Phase 3. In sections to follow we will discuss evidence that transfer effects did in fact appear in certain of the somatic measures. Table 9 summarizes information about extinction effects in Experiment I. Such effects could have occurred only on the C- and NC-trials, which were not reinforced during Phase 3; however, information about responses on buffer trials, when monetary reward was always present, is given for comparison. Inspection of Table 9 shows that for the Experimental Group, GSR falls regularly from an initial peak value of 24.3 (Q 3, Run 1) to a final value of 12.4 (Q 3, Run 2). This fall represents the combined effects of extinction and adaptation. In the Control Group, where only adaptation is operating, the overall decrease from the initial Q 3 to the final Q 3 is quite small. This comparison gives a rough idea of what proportion of the decrement can be attributed to extinction and adaptation respectively, but primarily it suggests that some process other than simple adaptation is at work in the Experimental Group.

TABLE 9

Extinction Effects during Phase 3: Experiment I

	Experimental Group						Control Group					
	Run 1			Run 2			Run 1			Run 2		
	Q3	Q2	Q1	Q1	Q2	Q3	Q3	Q2	Q1	Q1	Q2	Q3
BRL	44.5	37.2	39.4	49.4	44.4	44.1	38.1	32.7	32.1	33.7	34.0	36.1
GSR	24.3	16.9	15.5	13.7	14.0	12.4	13.0	12.6	6.3	9.5	10.5	10.1
GSRL	9.5	7.3	7.0	7.8	6.9	6.5	9.9	8.3	9.3	8.0	8.1	6.3
BR	15.0	13.8	30.5	22.8	16.4	19.1	17.3	21.9	15.0	24.5	11.5	14.7
BA	39 0	30.3	25.1	55.7	19.6	29.8	20.0	40.6	19.6	32.7	23.1	21.5
HR	9.3	7.5	5.1	8.3	7.4	9.3	7.2	6.3	8.1	5.9	7.2	7.7

Cell entries are means in units applicable to that particular measure (see previous tables).

The above is the true sequential order for each group when buffer trials are removed. Since each of the 3 questions occurs as the Critical Question on an equivalent number of occasions, it is possible to follow for each measure the effects of extinction and adaptation combined (Experimental Gp) or the effect of adaptation alone (Control Gp).

B. Effects of differential reinforcement

Before the digression we had discussed the basic phenomenon with which the present studies are concerned. Analysis of data provided by the C Group showed that the somatic responses recorded had already been to some extent conditioned to the concepts of true and false when the experiments began. How were they affected by the differential reinforcement procedure we applied in all three studies?

It is clear from the results of Phase 2 that not all of the somatic measures analyzed were significantly affected by the experimental treatment. GSR was quite the best measure, followed by HR. The breathing measures performed very variably.

For GSR, plots of cumulative effects of the treatments give an indication of the general nature of the processes involved. Reinforcement of somatic responses on the five FA trials was associated with systematic increments in responding which can best be described as a linear function of the number of reinforcements. Responses of the C Group on these trials also increased linearly, but at a slower rate. These are the results to be expected if the reinforcer were playing its intended role: responses of the C Group can be considered as a baseline upon which the direct effects of the reinforcements are imposed in the E Group. The fact that the divergence between the curves tends to increase with increasing reinforcement suggests that there is a carry over from one reinforced trial to the next; had the reinforcement been effective on single trials only, it would be expected that similar displacements of the E Group responses would have appeared on all FA trials.

The number of TA trials was 15 compared with five FA trials. It may be that the leveling off in the case of TA trials represents an adaptive process, which might also be evidenced on FA trials if a sufficient number were given. In order to learn more about these trends it would be necessary to extend Phase 2 considerably beyond the 20 trials used in the present experiments. A study in which the number of differentially reinforced trials served as the independent variable would also provide information about the optimal amount of reinforcement needed to produce maximum transfer effects during detection.

Earlier in this section we referred to the efficiency of the auditory stimulus as a reinforcer of somatic responses. Experiment III was designed to determine whether the loud tone played its role directly as a conventional UCS or indirectly as a cue for other intervening events between the stimulus questions and the subsequent somatic responses. Information about this key component is important in the analysis of the transfer ʻects in which we are particularly interested and in the determination of optimum conditions for maximimizing these effects during the practical procedures of interrogation. The results of Experiment III clearly showed that, at low intensities, the auditory stimulus did not produce systematic increments in somatic responses as did tones of the same frequency and duration, but of much higher intensity used in the first experiment. It was also the case, as will be seen below, that the low intensity stimulus was not effective in inducing transfer effects and, hence, in improving detection.

C. Transfer effects

Results already discussed demonstrated that, in our <u>Ss</u>, somatic responses had been conditioned to the concepts of true and false, without the use of special experimental techniques, prior to the start of the present experiments and that certain of the responses could be further differentiated by selective reinforcements of FAs. If the conditioned responses behaved in the usual manner, effects of the differential reinforcement should have transferred beyond the specific conditions under which the reinforcement occurred. Our basic research design provided tests for these transfer or generalization effects in Phase 3 of each experiment.

It would be expected that transfer effects would be most likely to appear in those somatic responses which had shown significant effects of differential reinforcement during Phase 2 of the experiment, although "latent" effects of the reinforcement cannot be ruled out on <u>a priori</u> grounds. Analysis of the results of Experiment I in terms of between- and within-groups differences showed that significant transfer effects did indeed occur, but not for all somatic measures studied. Again GSR was the most consistent measure, followed by HR and variable results from the breathing measures.

D. Detection of deception

Transfer effects of the kind just discussed could be put to use in interrogation aimed at the detection of deception. This was one of the reasons why the present experiments were designed within the context of a detection situation. The usefulness of a period of differential reinforcement prior to the interrogation proper can be best evaluated by the results of Experiment I, which provided a prototype of the revised detection procedure. Presumably the effects of the selective reinforcement of false statements would be to increase the differences between somatic responses to FAs and TAs, thus increasing the accuracy of detection during the subsequent interrogation period.

The results of Experiment I showed that detection was in fact superior following differential reinforcement. This held for all somatic measures, except breathing rate, although the superiority was not always statistically significant. In all instances detection within the E Group was better than chance; with the exception of heart rate, this was also true of the C Group. The latter result was to be expected since, as we pointed out earlier, the conditioned somatic responses had already been established before Ss participated in the experiment. The major conclusion remains, however, that differential reinforcement was associated with superior detection.

The fact that there were differences among the various somatic measures in the extent to which they exceeded chance in the detection of deception suggests a further step in the analysis of results. Detection as a practical procedure is based upon within-subject comparisons of somatic responses to critical and non-critical questions. Detection might be maximized by some weighted combination of somatic responses in contrast to the use of single responses as in the present report. Such a combination may be determined empirically by the use of the statistical technique of discriminant function analysis, an approach which we are applying to data now being gathered.

From the practical point of view the use of semantically conditioned somatic responses in interrogation may experience serious problems if Ss are sufficiently sophisticated to employ what we have called "confusional tactics". If the risks of being subjected to interrogation are sufficient, personnel might well be trained in the use of these tactics. It is possible that pre-interrogation exposure to selective reinforcement might make the differences between somatic responses to true and false statements more resistant to such tactics. Experiment II was designed to study this possibility. The results showed that the tactics can be very effective, although there was some indication that detection was still superior following differential reinforcement. Further research directed toward improving the efficiency of the differential reinforcement procedure may well indicate means by which this superiority can be enhanced.

We are also interested in the ways in which differential reinforcement, transfer effects, and detection are affected by certain classes of drugs. At present the effect of a central nervous system stimulant at various dose levels is being studied. The possibility that electric shock may prove a better reinforcer than loud noise is also being investigated.

Finally, we wish to emphasize again that the three experiments described in this report are the first in a series of studies designed to provide basic information about the semantic conditioning of somatic responses. As the first they have provided some information and, perhaps most importantly, have raised questions which can be answered empirically. From the point of view of interrogation, the present experiments have employed a prototype procedure which may have useful applications, but which needs further validation under the conditions of actual interrogation.

VIII. REFERENCES

Davis, R. C., Siddons, G. F., and Stout, G. L. Apparatus for recording autonomic states and changes. Amer. J. Psychol., 1954, 67, 343-352.

Davis, R. C., Buchwald, A. M., and Frankman, R. W. Autonomic and muscular responses, and their relation to simple stimuli. Psychol. Monog., 1955, 69, No. 20, 1-71.

Davis, R. C. Physiological responses as a means of evaluating information. In A. D. Biderman and H. Zimmer (eds.), The Manipulation of Human Behavior. New York: Wiley, 1961.

Ellson, D. G., Davis, R. C., Saltzman, I. J., and Burke, C. J. A report of research on detection of deception. Contract Nonr-18011, Indiana University, 1952.

Feather, B. W. Semantic generalization of classically conditioned responses: A review. Psychol. Bull., 1965, 63, 425-441.

Krasnogorsky, N. I. Physiology of the development of children's speech: Collected Works. Vol. 1. Moscow, 1954.

Kubis, J. F. Studies in Lie detection: Computer feasibility considerations. RADC-TR 62-205, 1962.

Lacey, J. I., and Smith, R. L. Conditioning and generalisation of unconscious anxiety. Science, 1954, 120, 1045-1052.

Luria, A. R., and Vinogradova, O. S. An objective investigation of the dynamics of semantic systems. Brit. J. Psychol., 1959, 50, 89-105.

Markosyan, A. A. On the interaction of two signal systems in involuntary processes. In: Proceedings of the conference on psychology, 1-6 July, 1957. Moscow: Acad. Ped. Sci., 1957.

Marushevsky, M. On the interaction of two signal systems in vascular reactions. Vopros. Psikb., 1957, 1, 78-97.

Orlansky, J. An assessment of lie detection capability. Tech. Rep. 62-16, Institute for Defense Analysis, Declassified version, 1964.

Razran, G. A quantitative study of meaning by a conditioned salivary technique (semantic conditioning). Science, 1939, 90, 89-91.

Razran, G. Semantic, syntactic, and phonetographic generalization of verbal conditioning. J. exp. Psychol., 1949, 39, 642-652. a.

Razran, G. Stimulus generalization of conditioned responses. Psychol. Bull., 1949, 46, 337-365. b.

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

Riess, B. F. Semantic conditioning involving the galvanic skin reflex. J. exp. Psychol., 1940, 26, 238-240.

Schwarz, L. A. Knowledge of the word and its sound form as a conditioned stimulus. Bull. exp. Biol. Med., 1948, 25, 292-294.

Schwarz, L. A. Knowledge of the word and its sound form as a conditioned stimulus. Bull. exp. Biol. Med., 1949, 27, 412-415.

Volkova, V. D. On certain characteristics of the formation of conditioned reflexes to speech stimuli in children. J. Physiol. (USSR), 1953, 39, 540-548.

Worrall, N. Unpublished data, Contract Nonr 908-15. Indiana University, 1963

Zimmer, H. Current Work. Cited by J. Orlansky, An assessment of lie detection capability. Tech. Rep. 62-16, Institute for Defense Analysis, Declassified version, 1964.

APPENDIX A

List of Questions used in Phase 2 of each Experiment together with Truthful Responses.

1.	Do you occasionally put off things which ought to be done sooner?	YES
2.	Is it true that you were bribed to take part in this experiment?	NO
3.	Have you ever felt like swearing?	YES
4.	Are you now over the age of 45?	NO
5.	Do you prefer dental extraction without anesthesia?	NO
6.	Can you ever be accused of not paying full attention in class?	YES
7.	Have you ever worried about anything?	YES
8.	Have you ever had diarrhea?	YES
9.	Have you ever had a headache?	YES
10.	Is it true that the average income of the female population in the U.S. is higher than that of the male population?	NO
11.	Have you occasionally felt conflict between the demands of work and play?	YES
12.	Have you ever felt self-conscious when called upon at a social occasion?	YES
13.	Are you telling the truth to every question?	NO
14.	Have you ever been imprisoned for a major crime?	NO
15.	Have you ever daydreamed of being famous?	YES
16.	Have you ever suffered from indigestion?	YES
17.	Was President Kennedy a member of the Catholic Church?	YES
18.	Have you resided in Russia for a period of longer than five years?	NO
19.	Is the communist ideology opposed to the general principles of Western capitalism?	YES
20.	Have you ever wished for money to buy more of life's luxuries?	YES

APPENDIX B

List of questions used in Phase 3

Critical Question (Crit Q) :

Either Q1. Did you take the master key?

or, Q2. Did you take the wristwatch?

or, Q3. Did you take the fountain pen?

Which of the above questions was the Crit Q for a given S depended upon his actions in the initial theft phase of the experiment.

Non Critical Questions (Non Crit Qs) :

These were defined as the two remaining questions after the Crit Q had been excluded.

Neutral Questions (Neut Qs) :

Q4. Did you answer most of the questions in Part One truthfully?

Q5. Is this an experiment in lie detection?

Q6. Are you at present enrolled in this university?

Q7. __________*

Presentation Order of the Above Questions was :

5 - 7 - 3 - 4 - 2 - 6 - 1

and 5 - 7 - 1 - 4 - 2 - 6 - 3

*The wording of this neutral question may be obtained from Dr. Worrall at present at the Department of Anatomy, University College London, Gower St., London, England. It was not specified here in order to avoid further delay in the preparation of this report.

APPENDIX C

Instructions for Subjects

In front of you are three gray boxes each having different but potentially valuable contents. PICK UP ONE BOX AND OPEN IT - DO THIS NOW - DO NOT DISTURB THE OTHER TWO BOXES.

You now have the opportunity to commit a "theft". You may place the contents of the box in your pocket or purse. What you take is yours to keep until the end of the experiment when you exchange it for a bonus of $2.00 PROVIDED you can successfully deceive the lie detector. On the other hand you may not wish to take anything in which case of course you cannot win the $2.00.

Thus you have a choice of taking nothing (and sitting in this room for the next 45 minutes without a chance to win any money) or of taking what you see and having an excellent chance of beating the lie detector and also making a handsome profit.

You are promised that there is NO trick to this - for example, if you think we are bound to guess what you took because all the boxes contain the same thing you are quite mistaken (as you will see at the end of the experiment). We would like you to accept the challenge.

AFTER FOLLOWING THE ABOVE INSTRUCTIONS, PLEASE LEAVE THE ROOM.

Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Psychology Department Indiana University Bloomington, Indiana	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Original Research

5. AUTHOR(S) (Last name, first name, initial)

Worrall, Norman
Russell, Roger W.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Dept. of the Navy Office of Naval Research ~~Washington 25, D. C.~~

13. ABSTRACT

Differential semantic conditioning of somatic responses was studied in three experiments for its theoretical importance and for its practical possibilities in improving the detection of deception. The conditioned stimuli were the concepts of "true" and "false" respectively, while the unconditioned stimulus was a loud tone. The procedure was successful for the GSR in particular. Although confusional tactics were effective, their effectiveness was reduced by the conditioning procedure, which itself was effective only if the tone was loud.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT

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