THE OPERANT CONDITIONING OF CONVERSATION¹

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Human conversation is a natural place to begin the study of social responses. In a conversation, a number of individuals use one another's responses as cues for their own behavior. So long as a conversation is being held, the speakers must talk in some order. Four experiments were conducted to test whether differentially reinforcing a group of speakers can bring the order of speakers under experimental control. The results are all consistent with the hypothesis. The paper also devises and evaluates different procedures for studying conversational sequences and examines associated statistical problems.

One describable feature of any conversation is the order in which the speakers converse. This order may be an important property of social behavior. These experiments were designed to test whether differentially reinforcing a group of speakers, when the contingency respects the order in which they have spoken, would tend to increase the frequency of speaking in that order.

EXPERIMENTAL PROCEDURE

Several Ss are asked to carry on a conversation in order to reach a series of unanimous decisions on which of several possible solutions to a problem is the correct solution. After each decision, the instructions require that the group stop the conversation and wait silently until it is informed whether or not its solution is correct. Each unanimous decision constitutes one "trial."

Speakers in a three-person group are designated A, B, and C. The record of conversation may look like this:

- (a) Trial 1—ABCABCA
- (b) Hypothesis X
- (c) Silence
- (d) Intervention
- (e) Trial 2—CBACBA . . .

The first item (a) is a list of the sequence of all speakers during that trial. Next (b), there is an indication of the hypothesis the group chose unanimously which brought an immediate end to (a) and ushered in (c), leading then to (d). The experimenter's intervention consists of telling or signalling the group that its hypothesis is correct or incorrect. What the group is told is determined by some property of (a) which is the response the experiment is designed to bring under control. In no case is the whole of (a) taken into account. Immediately after (d), the group begins (e) and the whole process is repeated without interruption, with the number of trials ranging from 50 to 165. Length of an S's speech or of a group's trial is not fixed, and experimental sessions last from 30 min to more than 2 hr.

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RESULTS

Experiment I

In the first experiment,³ four college students were seated at random around a

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table on which there were two stimulus cards. Cards I and X of the standard Rorschach series were used. They were told that they were participating in an experiment in mental telepathy. It was their job to send messages telepathically to a "receiver" (who was a role player) in an adjoining room. They were asked to discuss and decide which of the two messages on the table to try to send to the receiver. They were encouraged to relax and to use their imaginations freely. As soon as they all agreed on a single message, they were asked to stop talking immediately and concentrate on that message as they waited for the receiver to come into the room. The receiver indicated which message had been received by pointing and saying "this."

Two of the four Ss, designated A and B, were selected at random as experimental Ss. The behavior of the remaining Ss was completely disregarded. During each trial, a record was kept of the order in which A and B spoke.

A trial was reinforced; *i.e.*, the receiver claimed to have correctly received the message selected by the group, only if the last utterance of B followed the last utterance of A. Attention was paid to the last few speakers in the trial on the assumption that a group learns a social response more effectively when the delay between the response and its reinforcement is at a minimum. The following is a sample protocol:

<i>Trial</i>	<i>Sequence</i>	<i>Intervention</i>
1	ACBDCBDACBA	not reinforced
2	CBACBCAB	reinforced
3	DBACBACBD	reinforced
4	DCACDBADC	not reinforced

The psychological hypothesis is sufficiently straightforward: The frequency of AB is expected to increase as a function of the number of reinforced trials. On the other hand, the statistical hypothesis leaves some room for choice. One possibility is to take a sample of the behavior from an early part of the experiment and another from a later part and test the difference between the two observed frequencies. A second possibility is to make some use of a theoretical frequency. Irrespective of the individual frequencies of A and B, they should appear in sequence equally often as AB or BA.

Neither of these approaches is ideal. The first approach is a rather stringent test. Because the experimental conditions have been in effect throughout the 50-trial experiment, a comparison of the early trials with the later ones is really a test of the difference between two levels of the experimental effect. A much longer experiment would minimize this factor. The addition of an initial "emitted behavior" or operant period in which no reinforcement is given would provide a base line for comparison with the achieved level of learning. Both of these solutions make for less economical use of experimental time than in this experiment.

The expected frequency approach is considerably more efficient for these data. It assumes a level of emitted behavior and allows all observations to be reckoned as a measure of the experimental effect. The disadvantage of such an approach is the degree of uncertainty associated with the assumption, namely, that the pre-experimental level of $AB=BA=50\%$. The assumption is probably accurate for the sampling of a large number of groups, but any conclusion based on the performance of a particular group, or two or three groups, is open to question.

One way to test the assumption for a particular group is to compare that group's performance in a block of early trials with the expected frequencies, accepting the assumption as tenable if the null hypothesis ($AB=BA$) cannot be rejected. This procedure is not free from defects either; with a small sample size, the probability of accepting the null hypothesis is high if the true difference is not large. On the other hand, the fact that the experimental conditions are in effect during the first block of trials might have the opposite effect on the null hypothesis. Recognizing the difficulties of both the empirical and the theoretical approaches, the latter was arbitrarily chosen in the analysis. In recent studies, as yet unpublished, base-line measures were obtained by using random reinforcement procedures.

The results of Experiment I are given in Table 1. The pattern AB occurred in 35 trials out of a total of 50. This proportion ($7/10$) is significantly greater than the expected $1/2$ ($\chi^2 = 8.0$; $P < .01$). The results in the first set of 25 trials (14 out of 25) look different enough from the second set (21 out of 25) to cast

serious doubt on the possibility that AB would have been the more frequent pattern in the absence of the experimental conditions.

Table 1
Frequency of Two-Person Verbal Sequences
in Experiment I

Trials	Sequence	
	AB	BA
1-5	1	4
6-10	3	2
11-15	3	2
16-20	4	1
21-25	3	2
Total	14	11
26-30	5	0
31-35	3	2
36-40	4	1
41-45	5	0
46-50	4	1
Total	21	4
Grand Total	35	15

Experiment II

A second experiment was designed to permit a test of the hypothesis that a *three-person sequence* can be conditioned. Three Ss took part in this 125-trial experiment, and in each trial the last three speakers were recorded. Because no speaker can precede himself, each trial has 12 possible outcomes: ABC, ACB, BAC, BCA, CAB, CBA, ABA, ACA, BAB, BCB, CAC, or CBC. The last six of these (hereafter called homogeneous patterns)

were expected to occur infrequently because of the nature of the instructions emphasizing *group* decision. And this was the case. In all, these patterns occurred 34 times out of a total of 125. (See Table 2.) For purposes of the analysis to follow, the trials with homogeneous outcomes are omitted.

Two of the six heterogeneous patterns, ABC and BAC, are of special interest. The response ABC was chosen as the one to be reinforced. The expectation is that the frequency of ABC will increase as a function of reinforcement. But an increase in ABC is not a guarantee that this specific conversational pattern has been conditioned. Suppose that C alone learns to speak last in every trial. In this case, a critical test is that of the difference between the frequency of ABC and BAC. Because these are the only two three-person outcomes in which C can occur last, a preponderance of ABC over BAC would be evidence that the social response has been conditioned.⁴

Table 2 gives the results of Experiment II. The response ABC occurred a total of 34 times out of 91 heterogeneous trials. This ratio is significantly greater than the 1/6 chance ex-

⁴So far, we have ignored the possible influences upon the results of each individual's overall rate of responding. In a three-person situation in which no person may precede himself, the upper limit for any participant is slightly more than 50% of the total number of speeches. If C learned simply to talk a great deal, to a degree approaching the limit, the frequency of outcomes which include C would increase relative to those outcomes which do not. It would have a still greater effect on those homogeneous outcomes which include C as both ultimate and antipenultimate speaker (*i. e.*, CAC and CBC). However, this effect would not alter the significance of a difference between ABC and BAC.

Table 2
Frequency of Three-Person Verbal Sequences
in Experiment II

Trials	Sequence						Homogeneous					
	Heterogeneous											
	ABC	ACB	BAC	BCA	CAB	CBA	ABA	ACA	BAB	BCB	CAC	CBC
1-25	5	2	4	1	3	3	0	1	1	2	3	0
26-50	7	1	4	3	1	2	1	1	1	1	1	2
51-75	7	1	4	2	2	2	0	0	1	1	1	4
76-100	8	2	3	1	0	2	0	0	1	3	4	1
101-125	7	0	7	2	3	2	0	0	0	1	2	1
Total	34	6	22	9	9	11	1	2	4	8	11	8
Grand Total			91						34			

pectancy ($\chi^2 = 48.0$; $P < .001$). The difference between ABC and BAC is in the predicted direction, but it is not significant ($\chi^2 = 2.6$; $P < .10$).

The frequency of ABC when plotted against trial number lacks some of the properties of a typical acquisition curve. The correct response occurred first at the second trial, and then it did not occur again until the 22nd trial. At this point, it shows an upward spurt which is maintained but does not accelerate further during the remainder of the experiment. (See Table 2.) The Ss exhibited mounting impatience with the experiment, beginning somewhere between trial 50 and 100. This impatience grew to such proportions between the 100th and 125th trial that the experiment which had been planned for 150 trials had to be terminated after 125 trials in a total time of 2 hr and 45 min.

REVISED EXPERIMENTAL PROCEDURE

The work following Experiment II was devoted primarily to increasing the amount of information obtained per unit time, simplifying the instructions, and improving the conditions of observation. To accomplish these goals, a number of innovations were made in (a) the position of the experimenter, (b) the form of reinforcement, (c) the nature of the task, and (d) the method of recording data.

(1) In the first two experiments, the experimenter was in full view of the Ss. This led to difficulties on two counts. First, it was a possible source of contamination. The Ss may have been responding to unintended cues presented by the experimenter. Second, the continued presence of the experimenter made it possible for the group to communicate with him in spite of instructions to the contrary, thus disrupting the flow of conversation. For these reasons, and with the knowledge of the Ss, the experimenter was removed to the other side of a one-way screen.

(2) Reinforcement delivered personally by a serious-looking stranger added interest to the task but was wasteful of experimental time. A tone defined as "correct" and a buzzer defined as "incorrect" replaced the human receiver, with the result of a saving in time greater than 50%.

(3) The task of the Ss was altered in two respects. Instead of looking at several stimulus

cards and deciding among them, the Ss are seated around a table on which a bank of different-colored lights is arranged in a circle. The number of lights can be varied from one to six. Each S has before him a small control box with a number of buttons on it corresponding in number and color to the lights in the center of the table. A central light can be turned on only if all three Ss press the appropriate button. The light remains on as long as all three buttons are held down.⁵ The Ss are asked to decide unanimously among the colors and to turn on the appropriate light the instant a decision is made and to keep it on while remaining silent until they are signalled right or wrong. This serves to bring a more clear-cut finish to each trial, to inhibit conversation while waiting for reinforcement, and to facilitate recording of hypotheses made by subjects.

Another change in the task was to instruct the Ss that they were to play a guessing game rather than to attempt mental telepathy. They were told that the experimenter has a long list of color names in the next room comprised in the colors before them, and they were to guess the items in this list. The effect of this change seems to depend on the attitudes of the Ss. It may reduce interest in the task, but it also prevents the extremely hostile disruptive reaction observed in one S in the second experiment who was avowedly anti-ESP. The guessing-game procedure may be more nearly free of complications for most Ss.

(4) A persistent difficulty is obtaining an accurate record of the sequence of speakers. This is essential, not only as a means of measuring the experimental effect, but also for deciding, on the spot, whether or not a trial is to receive reinforcement. Incorrect reinforcements may entirely wash out the effect of the independent variable. Sound recordings of the experimental sessions were made, but they offered little help as a post-meeting accuracy check because of the difficulty of identifying voices, particularly in speeches of only one or two words.

In discussing observer reliability, some of the reactions of Ss to the experimental procedure should be described. They have expressed a wide range of attitudes, ranging from a request from members of one group

⁵The experimental apparatus was designed and constructed by Bernard Tursky, Instrumentation Engineer.

to "do it again for a hundred trials" to quite negative sentiments in another.

Apart from these group differences, some of the important determiners of behavior seem to be (a) the per cent reinforced trials, (b) the number of hypotheses the group is asked to choose from, and (c) the ratio of (a) to (b). In Experiment I, two stimulus cards (*i. e.*, two possible hypotheses) were presented to the group. This matched very well with the chance probability of the response. The AB sequence would occur about one-half the time by chance; and because the presence of two stimuli led to the same subjective probability estimate, the experiment made sense to the Ss. At the beginning, they were correct in about one-half of the trials, and gradually the ratio changed in the direction they would expect if mental telepathy were taking place.

In Experiment II and in subsequent experiments, the sequential response sometimes had an expectancy different from 50%. When the sequential response is expected to occur in one out of six trials, the choice of one out of two hypotheses would tend to make the group feel that it was not doing well, even after the rate of the response had increased appreciably.

In both Experiments I and II, we were careful to create some sort of correspondence between these two sets of probabilities. In the second experiment, in which the correct sequence response was expected to occur by chance somewhat less often than in 1/6 of the trials, the group was given six hypotheses to choose from. This rather precise matching of the two sets of probabilities proved to be not entirely adequate. The rate of the correct response increased appreciably, and so did the rate of reinforcement. Nevertheless in postmeeting questionnaires and interviews, the group felt that the experiment had been a failure.

In some groups, the procedure resulted in so much frustration that the Ss were unwilling to carry out the instructions. A number of solutions were attempted; but, finally, the sequence response itself had to be changed for one with a higher probability. The most successful combination proved to be three stimuli and a sequence response with probability .50. With these values, the groups were compliant, trials were short, and task satisfaction was relatively high.

The variety of these behaviors was reflected in differences in interobserver reliability scores gathered on several groups. Two observers, one experienced and one inexperienced, kept a record of an 80-trial experiment. In this experiment, the group was asked to choose from six hypotheses; the expected frequency of the sequence response was somewhat less than 1/6; and the final three speakers were focussed upon. On 17 of these trials, one or both of the observers were unable to record complete data. Of the remaining 63 observed trials, the two observers were in complete agreement 18 times, or 29% of the time. This result is typical for the groups that worked under conditions of low rate of reinforcement.

When the experimental procedure was less frustrating, observation seemed easier and the data more reliable. In a 165-trial experiment (Experiment IV, discussed below), in which the group was asked to choose from three hypotheses and the expected frequency of the sequence response was 1/2, and in which the last two speakers were focussed upon, two observers produced incomplete data in 43 trials. Of the remaining 122 trials, the observers were in complete agreement in 112 trials, or 92% complete agreement.

RESULTS

In both Experiments III and IV, the revised procedures discussed above were used, and reliable measures were found of the order of conversation. The Ss in each group were three boy scouts of fairly equal rank in their organization who knew one another before the experiment but were not close friends. The colored-light apparatus with three possible hypotheses was used; the instructions were those of the guessing game task. Reinforcement was in the form of a tone signifying "correct" and a buzzer signifying "incorrect."

The last two speakers in each trial were recorded, giving six possible outcomes: AB, BC, CA, BA, CB, and AC. Positive reinforcement was given after every occurrence of AB, BC, and CA (clockwise patterns). The remaining three outcomes (counterclockwise patterns) received negative reinforcement. By chance, the conversational pattern to be reinforced is expected to occur half the time.

We predicted that the reinforced clockwise patterns would occur more frequently than

Table 3
Frequency of Two-Person Verbal Sequences
per block of 15 trials in Experiment III

Trials	Verbal Sequence						One Speaker Only
	AB	BC	CA	BA	CB	AC	
1-15	3	3	3	1	2	2	1
16-30	1	2	2	3	3	2	2
31-45	3	3	3	1	2	3	0
46-60	2	5	2	0	4	2	0
61-75	3	3	3	1	2	3	0
76-90	6	5	1	1	1	1	0
91-105	2	8	2	0	3	0	0
106-120	3	3	2	1	6	0	0
121-135	0	5	1	3	1	2	3
136-150	2	4	2	2	1	0	4
151-165	0	6	0	4	2	0	3
Total	25	47	21	17	27	15	13
		Clockwise Patterns			Counterclockwise Patterns		
Grand Total		93			59		13

the counterclockwise patterns and that each clockwise pattern would occur more frequently than its counterclockwise mate (matched for individual rates of responding), *i.e.*, AB > BA, BC > CB, and CA > AC.

Tables 3 and 4 summarize the results for Experiments III and IV, respectively. In Experiment III, both the general predictions (total clockwise > total counterclockwise) and the specific predictions (AB > BA,

Table 4
Frequency of Two-Person Verbal Sequences
per block of 15 trials in Experiment IV

Trials	Verbal Sequence						One Speaker Only
	AB	BC	CA	BA	CB	AC	
1-15	2	5	3	0	1	0	4
16-30	2	1	1	1	6	2	2
31-45	1	3	2	1	3	1	4
46-60	0	4	1	2	3	2	3
61-75	1	5	2	0	5	1	1
76-90	1	3	3	1	2	1	4
91-105	0	5	0	0	2	3	5
106-120	1	7	0	1	1	1	4
121-135	1	3	1	1	2	1	6
136-150	0	5	1	0	1	0	8
151-165	1	7	0	0	0	1	6
Total	10	48	14	7	26	13	47
		Clockwise Patterns			Counterclockwise Patterns		
Grand Total		72			46		47

Table 5
Chi Square Tests
on Frequencies of Verbal-sequence Pairs

<i>Sequence Pair</i>	<i>Clockwise</i>	<i>Counterclockwise</i>	χ^2	<i>Degrees of Freedom</i>	<i>P</i>
Experiment III					
AB BA	25	17	1.5	1	$P < .15$
BC CB	47	27	5.4	1	$P < .01$
CA AC	21	15	1.0	1	$P < .20$
Total	93	59	7.5	1	$P < .005$
Experiment IV					
AB BA	10	7	0.5	1	$P < .25$
BC CB	48	26	6.5	1	$P < .01$
CA AC	14	13	0.03	1	$P < .45$
Total	72	46	5.8	1	$P < .01$

BC > CB, and CA > AC) are in the expected direction, although the latter differences are significant only for the BC-CB comparison. Table 5 shows the chi square values.

The results of Experiment IV closely resemble those for Experiment III. The total clockwise versus counterclockwise and the three specific pattern differences are all in the expected direction, although two of the latter are very small. Again, the BC-CB comparison yields the only significant difference. (See Table 5).⁶

The results of Experiments III and IV confirm the hypothesis that preselected conversational sequences would occur more frequently than others. The results also indicate that not all of the three possible conversational patterns increased in frequency, but, rather only one of them. In Experiment III, this finding is highlighted in trial blocks 91-105 and 151-165; in Experiment IV, similarly, it is definite by trial block 91-105 and persists until the end of the trial run.

In effect, both groups appeared to learn a more specific social response, namely, of one person talking last, preceded by a specific other person, and not a general positional response (clockwise or counterclockwise). The next-to-last speaker functions as a discrimi-

native stimulus for a given speaker whose final response brings reinforcement.

Reinforcing a category of two-person sequences may have served to "shape up" a specific conversational sequence. Scrutiny of the results in Tables 3 and 4 indicates the relative fixing of a specific clockwise sequence at about the fourth trial block (46-60). This same sequence is relatively higher than each of the remaining sequences, trial block by trial block, until the end of the runs.

An interesting exception is apparent in trial block 106-120 in Experiment III: CB occurred six times, whereas in the previous block, BC occurred eight times. The reinforcement of conversation between two persons, B and C, in one direction, B to C, seemed to generalize to its reverse sequence, C to B. By the same token, Speaker A learned to be quiet during this particular section of the conversation.

No specific hypothesis was made about increases over time in the frequency of given conversational patterns as a function of the number of reinforced trials. Such a change was observed for the single sequence (BC), as Tables 3 and 4 show. However, the acquisition of this response does not follow an incremental path, but rather seems to become stabilized at some point along the way.

DISCUSSION

We have shown in this paper how the operant conditioning of serial order of con-

⁶The seat positions and clock patterns were not in fact the same for Experiments III and IV; and the specific verbal sequence was clockwise in one instance, and the reverse in the other. The learning was therefore not the same spatially in both groups. Results were expressed in similar terms for simplicity.

versation may be carried out. In postgroup interviews with subjects, not one noticed a connection between conversational sequence and getting the right answers, although several suspected that the guessing game was rigged in some way. During the experimental sessions themselves, Ss offered a great variety of complex and often inconsistent hypotheses to account for their increasing success in figuring out how the experimenter devised his list of colors.

The results of the studies are all consistent with the hypothesis that the order of speakers in a conversation can be brought under experimental control by manipulating the variable

of group reinforcement—success and failure—in a task in which the group has to make a number of unanimous decisions about a number of hypotheses. In each group, a conversational sequence became established at a given level after about 50 to 100 trials, or within a half-hour of conversation.

Further studies are now proceeding on the acquisition and extinction of conversational patterns in three-person groups and on the basic assumptions of the operant techniques used. The procedure is also being adapted to study the course and stability of other kinds of social responses under different conditions of group reinforcement.