REVISTA MEXICANA DE ANÁLISIS DE LA CONDUCTA 2005 NÚMERO 2 (DIC)
MEXICAN JOURNAL OF BEHAVIOR ANALYSIS **31**, 245-260 NUMBER 2 (DIC)

THE ROLE OF RESPONSE-REINFORCER CONTINGENCY ON ACQUISITION AND MAINTENANCE OF RESPONSES LEARNED BY OBSERVATION

EL PAPEL DE LA CONTINGENCIA RESPUESTA-REFORZADOR EN LA ADQUISICION Y MANTENIMIENTO DE RESPUESTAS APRENDIDAS POR OBSERVACION

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ABSTRACT

Results are reported of two experiments designed to evaluate the effects of different response-reinforcer relationships, both during the modeling phase and in the later maintenance phase, with respect to the performance of a novel response in observer pigeons. In experiment 1, three groups of observer pigeons were exposed, during the twelve-trial modeling phase, to a model trained to open a tube in order to receive food. A control group was not exposed to the model. Later, the groups were exposed to different response-reinforcer relationships: in one group, the relationship was contingent; in another, the relationship was non-contingent; in a third group, the relationship was negative and in the control group, the relationship was contingent. In experiment 2, three groups of observers were exposed, during the modeling, to a relationship that was non-contingent between the responses of the model

1. This experiment was supported by D.G.A.P.A.-U.N.A.M. IN309402. The final version of manuscript was concluded during sabatical year of Rosalva Cabrera. We are grateful to Abel Javier Zamora for his assist during experimental sessions.
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and the reinforcer. Subsequently, one of the groups was exposed to a contingent relationship, while the other two groups were exposed to a non-contingent relationship; the number of trials being varied between those two groups. The results showed that the acquisition of the response by observers was superior when the relationship between the responses of the model and the presentation of the reinforcer was contingent. With respect to maintenance of the responses, the data showed that the responses acquired by observation only remained in the repertoire of the observers when the contingent relationship between responses and reinforcers was maintained. The foregoing allows the argument that learning by observation, as with instrumental learning, is sensitive to variations in response-reinforcer contingency.

Keywords: learning by observation, correlation, response, reinforcer, acquisition, maintenance.

RESUMEN

Se reportan los resultados de dos experimentos diseñados para evaluar los efectos de diferentes relaciones respuesta-reforzador, tanto durante la fase de modelamiento como en la fase posterior, de mantenimiento, sobre la ejecución de una respuesta novedosa en palomas observadores. En el Experimento 1, tres grupos de palomas observadores fueron expuestos durante la fase de modelamiento a un modelo entrenado en abrir un tubo para recibir alimento en doce ensayos, un grupo control no fue expuesto al modelo; posteriormente, los grupos fueron expuestos a diferentes relaciones respuesta-reforzador; en un grupo la relación fue contingente, en otro grupo la relación fue no contingente y en el tercer grupo, la relación fue negativa; para el grupo control la relación fue contingente. En el Experimento 2, tres grupos de observadores fueron expuestos durante el modelamiento a una relación no contingente entre las respuestas del modelo y el reforzador; posteriormente, un grupo fue expuesto a una relación contingente, los dos grupos restantes fueron expuestos a una relación no contingente, variando el número de ensayos por sesión entre uno y otro grupo. Los resultados mostraron que la adquisición de la respuesta por los observadores fue superior cuando la relación entre las respuestas del modelo y la presentación de reforzadores es contingente; en cuanto al mantenimiento de las respuestas, los datos mostraron que las respuestas adquiridas por observación sólo permanecen en el repertorio de los observadores cuando se mantiene la relación contingente entre respuestas y reforzadores. Lo anterior permite argumentar que el aprendizaje por observación al igual que el aprendizaje instrumental es sensible a variaciones en la contingencia respuesta-reforzador.

Palabras clave: aprendizaje por observación, correlación, respuesta, reforzador, adquisición, mantenimiento

The present research into learning by observation in animals has demonstrated that a naive subject learns to perform a novel response more quickly if it has been afforded the opportunity to see that this response is followed by a reinforcer, e.g., food, as opposed to when that response has no programmed consequence or when the response is not predictive of the presentation of the reinforcer.

Nieto and Cabrera (2002) explicitly evaluated the effects of different response-reinforcer correlations in a model with respect to the subsequent acquisition of that response in observer pigeons. Their results show that the observer pigeons acquired the response of opening the inverted tube when they observed a positive correlation between the response and the reinforcer, but that they did not when they were exposed to random demonstrations between the response and the reinforcer, or to the reinforcer alone (See also Palameta and Lefebvre, 1985).

The bidirectional control procedures have also demonstrated that the response-reinforcer relationship determines the process of learning by observation, like as two response procedures, both show that when the observers have seen a model perform the same response in a different direction, or different responses that they correlate in a different way with the presentation of food, they preferentially emit the response that has been correlated in a greater proportion with the presentation of food (see Heyes and Dawson, 1990; Heyes, Dawson and Nokes, 1992; Zentall, Sutton and Sherburne, 1996; Akins and Zentall, 1996; Campbell, Heyes and Goldsmith, 1999; Voelkl and Huber, 2000; Nieto and Cabrera, 2003). However, the bidirectional control procedure have been found with a flaw: the performance of observers was the result of residual scents deposited on the apparatus (Mitchell, Heyes, Gardner and Dawson, 1999).

It is common knowledge that experimental research, into learning by observation carried out during the last decade, has identified that the acquisition of responses is a function of the correlation between the modeled response and the consequent presentation of the reinforcer, however, to date there do not exist data, produced in laboratory settings, that explicitly evaluate the maintenance of acquired responses by observation in the repertoire of the observers.

Carrying out this evaluation was of the utmost urgency, as much for the heuristic value that obtaining new data under conditions not previously explored, it, in itself, contains, as for the contribution that the data obtained may make towards clarifying the controversy that exists regarding the permanence of socially learned responses in the repertoire of the subjects that are learning.

In relation to this last aspect, some authors, such as Galef (1995) and Heyes (1996), propose that when an organism socially learns to perform a novel response, such response will remain in its repertoire if and only if it

receives adequate enviromental support, that is, if the performance of this response produces the same reinforcer. Meanwhile, authors like Rogers (1988) suggest that socially-learned responses remain indefinitely in the learners' repertoires.

As a consequence, two experiments were performed to experimentally evaluate whether a response acquired by observation is maintained in the behavioral repertoire of observers after modeling, when they are exposed to variations in the reinforcing contingencies.

EXPERIMENT 1

To date, we do not have knowledge of experiments that have explicitly evaluated whether the permanence (maintenance) of a socially-acquired response is a function of the response-reinforcer relationship in force at the time of the modeling.

Given the foregoing, the objectives of this first experiment were primarily to evaluate the acquisition of a response in observers that had been exposed to a modeling phase in which the presentation of food was contingent to the responses of the model. Above all though, it was sought to evaluate the maintenance of that response in a later phase, where the observers were exposed to different contingencies between their responses and the presentation of the reinforcement.

METHOD

Subjects

41 experimentally naive, adult pigeons were used, 40 of those were assigned as observers and one was pre-trained in the response and later used as a model. All subjects were deprived to 80% of their *ad libitum* weights during the course of the experiment.

Apparatus

Two identical experimental boxes, measuring 25.3 cm in length, 15.2 cm in breadth and 23.5 cm in height, were used. The boxes had bases and structures of metal covered entirely with black cardboard, with the exception of the front wall which was formed by a wire grating that had an opening 6 cm in diameter, located 7 cm from the floor, through which the pigeons could introduce and withdraw their heads. The boxes were located one in front of

the other (the modeling box for the model and the observation box for the observers). The boxes were separated by 30 cm and between them a metallic tray was placed and used as a feeding dish. In addition, in one side of each experimental box, a metallic structure with a fixed pin to sustain an opaque test tube, of 20 cm in height, was placed. This could hold 20 millet seeds and was sealed with a rubber stopper, of 2 cm diameter and 2 cm in height, that had a piece of wood measuring 4 x 1.5 cm attached to it perpendicularly. The tube was placed inverted at the top of the orifice and the subjects had to peck the wood until the stopper fell into the dish, and the millet seeds were made available.

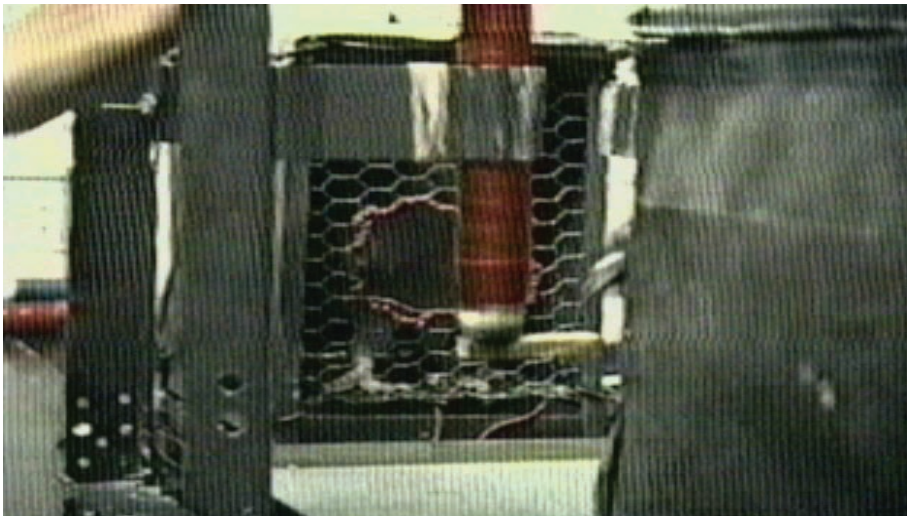

Figure 1. Photography of the apparatus used showing the opaque tube sealed with rubber stopper and wood.

Experimental setting

The experiment was carried out in a cubicle containing a table upon which the two experimental boxes were placed. Two researchers took up positions at opposite sides of the table. On the left side, a researcher prepared and presented the operandum, while the researcher on the right side registered the response occurrence in each of the trials, and timed both the duration of each trial as well as the intervals between trials.

Procedure

The procedure consisted of a preliminary training phase and three subsequent phases, described below:

Preliminary Training

The subject designated as model was trained by successive approximations to peck the wood attached to the stopper sealing the test tube until it had released the stopper. Each time the model would open the tube, 20 millet seeds would fall along with the stopper into the feeding dish, permitting the model to feed. This training was carried out until the model performed the response in all trials presented over seven consecutive sessions.

Habituation Phase

The observers were placed individually into the observation box for 15 minutes per day, over seven consecutive days. Two researchers were present throughout these periods.

Modelling Phase

Immediately after the final habituation session the modeling phase was begun. In this phase, the Experimental Groups (C-Contingent, C-Non contingent and C-Extinction, each n=10) were exposed to trained model, wich was placed in the modeling box and an observer was placed in the observation box. Each session comprised twelve consecutive trials; each trial involving the presentation of a tube sealed with a rubber stopper. The model had a maximum of one minute to peck the wood and cause the stopper to fall into the feeding dish along with the millet seeds. After one minute had passed, the tube was removed and, after an interval between trials of an average of 45 seconds length (ranging between 35-55 seconds), the next trial was begun. In all of the modeling trials, the response of opening the tube by the model was reinforced, by which means the observers were exposed to an entirely positive correlation between response and reinforcer, although never having access to the tube or the food produced by the responses of the model. A Control Group (n=10) was exposed to the tube sealed with the rubber stopper for twelve consecutive trials in the modeling box, but without the model being present. The tube was present for one minute and the interval between trials had an average duration of 45 seconds.

Maintenance Phase

The end of twelfth modeling trial saw the initiation of the first maintenance session, in which the observers were individually exposed to the sealed tube for the first time. The experimental group observers were randomly assigned to three new groups. In the C-Contingent Group (n=10), the observers were exposed to 12 trials where they had access to the seeds each time they emitted the tube-opening response. In the C-Non contingent Group (n=10), the observers were exposed to twelve trials divided into three types: a) four trials where they had access to the seeds upon emitting the response; b) four trials where they had access to the seeds without having emitted the response; the researcher removing the stopper at the start of the trial; and c) four trials where the tube did not contain seeds and, thus, even when the observers opened the tube they were not reinforced. The presentation order of the different types of trial was randomly determined . In the C-Extinction Group (n=10), the observers were exposed to 12 trials where the tube-opening responses were not reinforced. For its part, the Control Group was exposed to the sealed tube containing seeds in each of the 12 trials, in such a way that if the subjects pecked the wood until the stopper fell they would have had access to the food.

This phase comprised five consecutive sessions. The duration of the trials and the intervals between the trials were programmed in the same way as described for the modeling phase.

RESULTS AND DISCUSSION

The data obtained in this experiment confirm previous findings that the exposure of naive observers to a response-reinforcer contingency, via a trained model, promotes the acquisition by observation of such a response (Nieto and Cabrera, 2002, 2003), as all observers of the experimental groups opened the tube during the first session of being exposed to the sealed tube, whereas no subject in the Control Group, exposed only to the sealed tube, did so (Nieto and Cabrera, 2002, 2003).

Additionally, in the maintenance phase, it was observed that the response was maintained at high levels only when the observers were consistently reinforced; the subjects exposed to the non-contingent relationship between response and reinforcement, or to the omission of reinforcement, progressively stopping responding.

Figure 2 shows the number of observers of each group that emitted the tube-opening response during the five maintenance sessions. As you may observe, the number of observers in the Control Group remained at zero during

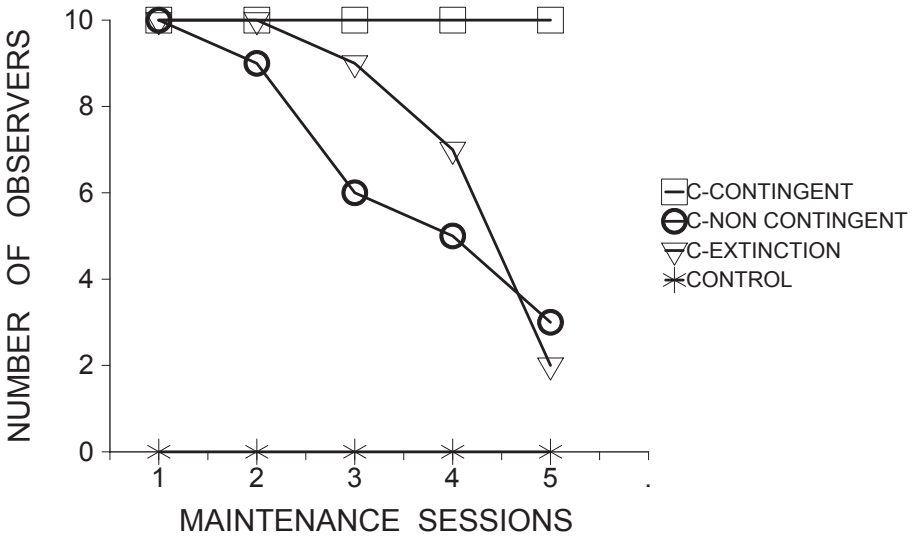

Figure 2. Number of observers performing the modelled response in each session in Experiment 1.

the entire phase. In the case of the experimental groups, 10 of the observers opened the tube during the first session. From the second session onwards, the number of subjects that kept responding changed due to the procedure employed. All of the observers in the C-Contingent Group maintained the response, while the number of the observers of the C-Non contingent Group and the C-Extinction Group decreased progressively to values of less than 3 for the final session.

A multifactorial variance analysis, that contrasted the number of observers that perform the modelled response in each session by each group indicated that the number of observers that emitted the response in each of the groups differed significantly, $F(3, 4) = 131.756$, $p < 0.001$. The effect of the sessions was also significant, $F(3, 4) = 13.2209$, $p < 0.001$, as was that of the interaction between groups and sessions, $F(3, 12) = 5.003$, $p < 0.001$.

Figure 3 shows the average percentage of trials with response to each of the groups of Experiment 1. It can be seen that the observers in the Contingent Group emitted the response, on the average, in 85% of the trials in the first maintenance session and that this percentage increased up to 100% in the final two sessions. Meanwhile, the subjects in the Non-contingent Group opened the tube in 95% of the trials of the initial session and this percentage gradually decreased to 25% of trials producing a response in the final ses-

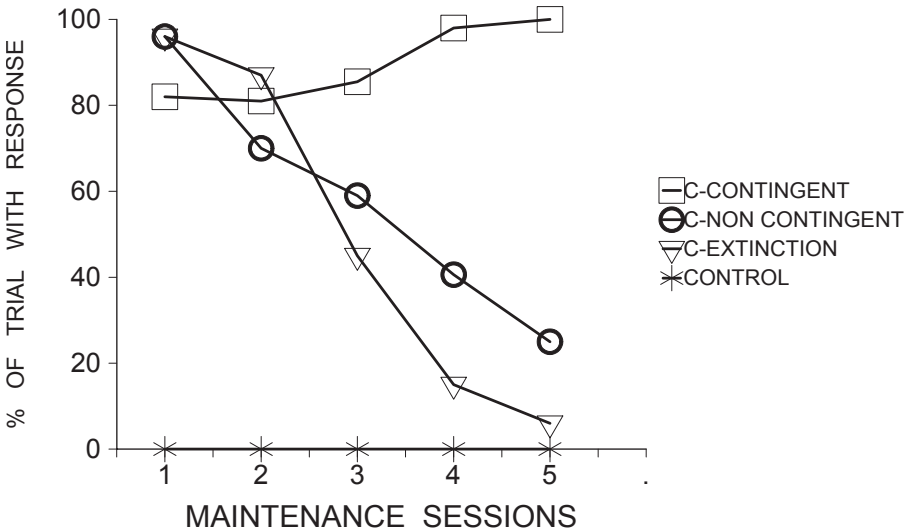

Figure 3. Mean percentage of trials with response for each group in each session in Experiment 1.

sion. Finally, the observers in the Extinction Group performed the response in 96% of the trials of the first maintenance session, although in the last session they only pecked the wood in 5% of the trials.

A multifactorial variance analysis, where the average of trials with response recorded by each observer in sessions by group was contrasted, revealed the existence of significant differences between groups, $F (3, 4) = 115.615$, $p < 0.001$, significant effects across the sessions, $F (3, 4)) = 13.502$, $p < 0.001$, and significant effects of the interaction between groups and sessions, $F (3, 12) = 9.119$, $p < 0.001$.

A categorical analysis of the data where the number of trials producing a response and those not producing a response, between the different groups, indicated that the groups differed significantly from the second maintenance session on: Pearson = 14.00 $p < 0.01$; this difference was maintained over the remaining sessions of the phase.

The results show that the maintenance of responses learned by observation depends on the reinforcement contingencies being similar to those observed during the modeling phase. All subjects of all experimental groups were exposed to a model that was reinforced for opening the tube in each of the trials, and this same contingency was experienced by the C-Contingent Group. In contrast, the C-Non contingent Group was exposed to a sequence

of trials designed to break with the response-reinforcer contingency, but without eliminating the occurrence of those events. This procedure produced the almost complete suppression of the response, even though the subjects actually received reinforcement in eight out of twelve of the trials. Lastly, the C-Extinction Group, where the presentation of the reinforcer was omitted during the maintenance phase, stopped responding in the final session.

EXPERIMENT 2

Experiment 1 showed the significant differences in the performance of the Extinction Group and the Non-contingent Group, relative to the performance of the Contingent Group, during the maintenance phase. These differences may be attributed to the fact that the contingent relationship between the response and the reinforcement, observed by the subjects during the modeling phase, was altered for the Extinction and Non-contingent Groups during the maintenance phase; implying that both the acquisition and the maintenance of responses learned by observation are functions of the contingency between responses and reinforcers (Galef, 1995; Heyes, 1996; Nieto and Cabrera, 2002, 2003).

The Non-contingent Group comprised the comparison group *par excellence*, given that it was the group where the response-reinforcer relationship was null, even though all other factors remained constant.

The second experiment controlled the different number of trials where the response and the reinforcement are presented, and that fact could be responsible for the different results discovered between the Contingent and Random Groups in Experiment 1. Thus, the Contingent Group received 12 trials per session where the responses and the reinforcer were presented, while the Random Group likewise received 12 trials per session, but where, in only eight of those 12, the response and reinforcer were presented. If the presentation of reinforcement and/or the response are sufficient to induce the occurrence of the response in the observers, it should be expected that increasing the number of non-contingent trials would favour an enhanced acquisition of the response in the maintenance phase. Consequently, in this experiment, a non-contingent group would be presented with a greater number of trials per session, in such a way that the number of trials where food was presented equalled the number of trials where food was presented to the Contingent Group of Experiment 1.

METHOD

Subjects

30 experimentally naive, adult pigeons were used; assigned as observers. The model was the same subject employed in Experiment 1. All subjects were maintained at 80% of their *ad libitum* body weight throughout the experiment.

Apparatus and experimental setting

The same as described in Experiment 1.

Procedure

The procedure employed was similar to that used in Experiment 1.

Habituation Phase

The observers were exposed to the habituation conditions described in Experiment 1.

Modeling Phase

In this phase all of the observers were exposed to a random relationship between the pecking response and the reinforcement of the model. Two groups of observers, NC-Contingent Group (n=10) and NC-Non contingent 12 Group (n=10), were exposed to a model that received 12 trials divided equally into three types: in four trials, the model pecked the wood/stopper assembly and, upon succeeding in removing it, received 20 millet seeds; in four trials, the model had access to the millet seeds without having to emit the response, as the experimenter removed the stopper simultaneously upon beginning the trial; and in the remaining four trials, the tube did not contain seeds, such that even if the model emitted the response it was not reinforced. In summary, the observers were exposed to a total of twelve trials in which a random correlation between the behavior of the model and the presentation of food was arranged. A third group of observers, NC-Non contingent 18 Group (n=10), was exposed to a model whose response-food relationship was also random, with the difference that this group was exposed to six trials of each type, that is, each session comprised a total of 18 trials. The presentation order of the different types of trial was randomly determined.

Maintenance Phase

Directly upon concluding the modeling phase, the first of the maintenance trials for each observer was begun. In the NC-Contingent Group, the observers were exposed to 12 trials where the observer attained access to the millet seeds each time it emitted the response. In the NC-Non contingent 12 Group, the observers were exposed to 12 trials divided equally into three types: a) four correlated trials (the observer received millet seeds upon emitting the response); b) four trials in which the observer was reinforced without having to emit the response; c) four trials where the reinforcer was not presented even if the observer responded. In the NC-Non contingent 18 Group, the observers were exposed to 18 trials in total, divided equally into the three types of trial described for the NC-Non contingent 12 Group, with the difference that each type of trial was presented six times. This phase had a duration of 5 consecutive sessions.

RESULTS AND DISCUSSION

The data obtained show that the exposure of naive observers, during the modeling, to a non-contingent relationship between the response of the model and its consequences, resulted in only 60% of the observers of the different groups acquiring the tube-opening response, and that they did so in less than 50% of the trials.

Figure 4 shows the number of observers that emitted the modeled response in each group over the course of the maintenance sessions. During the first session, only 6 of observers of the NC-Contingent and NC-Non-contingent 18 Groups, and 7 of the subjects of the NC-Non-contingent 12 Group, emitted the tube-opening response. This value remained constant in the subjects of the NC-Contingent and NC- No Contingent 18 groups during the subsequent maintenance sessions. A reduction in the number of subjects reponding was observed in the NC-Non-contingent 12 Group.

A multifactorial variance analysis, that contrasted the number of observers that perform the modelled response in each session by each group indicated no significant difference for either groups, $F(2,4) = 1.449$, $p > 0.05$; sessions, $F(2,4) = 0.266$, $p > 0.05$; or group x session interaction, $F(2,8) = 0.266$, $p > 0.05$.

Figure 5 shows the average percentage of trials with response, in each of the groups, during the five experimental sessions. It may be observed that the observers of the NC-Contingent Group responded in only 55% of the trials in the first session; this figure increasing slightly during the subsequent sessions. The observers of the NC-Non-contingent 12 Group opened the tube

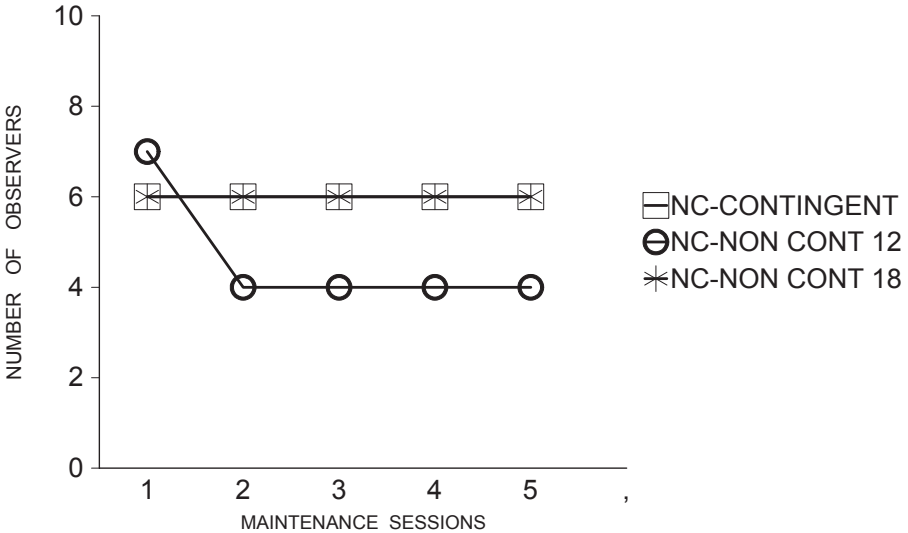

Figure 4. Number of observers performing the modelled response in each session in Experiment 2.

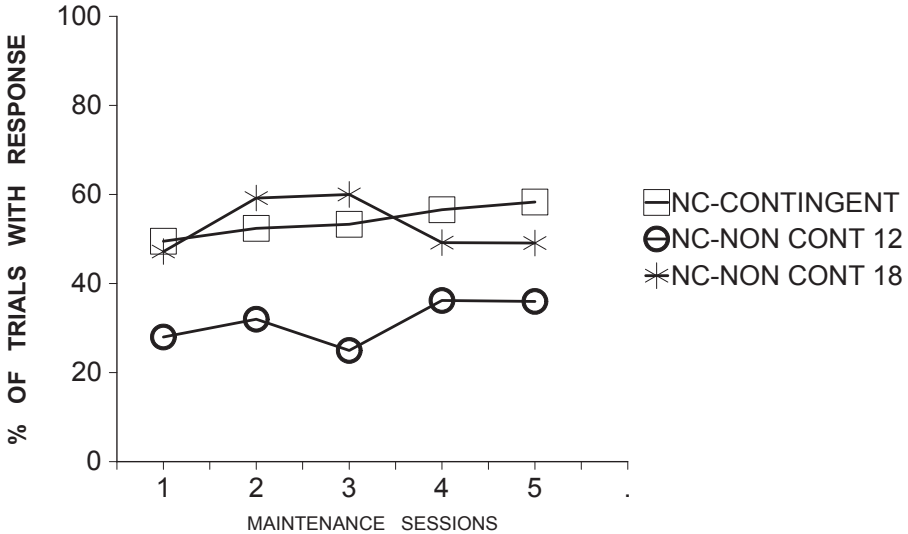

Figure 5. Mean percentage of trials with response for each group in each session in Experiment 2.

in 28% of the trials of the first session and in 36% of those comprising the last session. In the case of the NC-Non-contingent 18 Group, the observers responded in 47% of first session trials and demonstated fluctuations over the course of the following sessions.

A multifactorial variance analysis, that contrasted the average of trials with response recorded by each observer in sessions by group revealed that the groups differed significantly, $F(2,4) = 4.398$, $p < 0.05$, but that neither the sessions nor the groups x sessions interaction were significant, $F(2,4) = 0.118$, $p > 0.05$ and $F(2,8) = 0.146$ $p > 0.05$, respectively.

A Tukey test to evaluate specific differences between the groups indicated that the NC-Non-contingent 12 Group was significantly different than the NC-Contingent Group $p < .05$ and the NC-Non-contingent 18 Group $p < .05$, while between the NC-Contingent and NC-Non-contingent 18 Groups no significant difference was found $p > .05$.

These data show that the exposure to a random procedure during the modeling phase produces few response-acquiring observers, and that, even when these do respond, they do so at very low levels. This effect is maintained even though a positive contingency is established in an later phase, that is to say, the asyntotic level of responses is less when the observers have seen a model whose response is reinforced in a random way compared with when the response-reinforcer correlation has been positive during the modeling.

The fact that significant statistical differences do not exist between the NC-Contingent and NC-Non contingent 18 Groups shows the relevance of the number of reinforcers per session, as these groups demonstated trial percentages with responses superior to those of the NC-Non contingent 12 Group. Nevertheless, the values calculated for both groups are smaller than those registered by the Contingent Group in Experiment 1.

GENERAL DISCUSSION

The results of these experiments show that, for a response to be acquired by observation, it is necessary that the occurrence of reinforcement be consistently preceded by the modeled response. Demonstrations of this type of contingency appear to induce a greater propensity for observer response in the first acquisition session than when random contingencies are demonstrated. This may be appreciated from a comparison of the performances of the groups of experiment 1 with those of the groups of experiment 2, during their respective first maintenance sessions. However, experiment 2 showed that a random relationship response-reinforcement during the demonstration phase can induce the occurrence of the modeled response if the number of trials per session rises, although the number of subjects that responded, and the num-

ber of trials in which they did, were less than in the predictive condition. These data, in consequence, are consistent with earlier reports that argued that social learning of a novel behavior in observers is a function of their exposure to a positive relationship between the response and the reinforcer (Palameta and Lefebvre, 1985; Zentall, 1996; Nieto and Cabrera, 1994, 2003).

These data show, moreover, that the existence of a response-reinforcement contingency is necessary in order to maintain the responses learned by observation. In experiment 1, the performance of the observers of the Contingent Group was maintained and improved as the sessions progressed, while the observers of the Non-contingent and Extinction Groups progressively stopped responding. The performance of the NC-Contingent Group in experiment 2 showed that the exposure of the observers to the random response-reinforcement contingency during the demonstration phase produces deteriorations in acquisition that are not completely reversed by the later exposure to the positive response-reinforcement contingency in the maintenance phase. In the same way, those data show that the exposure to random occurrences of response and reinforcement induce the occurrence of the response and that, although its maintenance appears to depend on the rate of non-contingent reinforcers per session, the asyntotic response levels were inferior to those of the groups exposed to positive response-reinforcement relationships in both phases.

These data support that proposed by Galef (1995) and Heyes (1996) when arguing that a socially-acquired behavioral pattern is maintained, in addition to being diffused and converted into a tradition within a population, when the environmental support is adequate for its production.

In summary, the data reported here may be added to the growing experimental evidence that shows that the contingent response-reinforcer relationship in the modeling determines the level of acquisition by observation of a novel response (see Galef, 1995; Heyes, 1996; Palameta and Lefebvre, 1985; Nieto and Cabrera, 1994, 2002, 2003) Moreover, they experimentally demonstrate that, for the maintenance of a response acquired by observation the positive response-reinforcer correlation is necessary, whether or not the response has been socially acquired (Galef, 1995; Sherry and Galef, 1984; Laland, 1996). Then, the data obtained in this research showed that response-reinforcer relationship determines the learning by observation processes as in instrumental conditioning, which is agreed with Zentall´s proposition about learning by observation or imitation can be considered as a type of instrumental learning.

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