International Journal of Psychological Research
ISSN: 2011-2084
ijpr@usbmed.edu.co
Universidad de San Buenaventura
Colombia

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International Journal of Psychological Research, vol. 1, núm. 1, 2008, pp. 13-19
Universidad de San Buenaventura
Medellín, Colombia

International Journal of Psychological Research 2008. ISSN 2011 - 7922
Vol. 1, No. 1, pp. 13 - 19

Contextual Control of Conditional Discrimination of the Own Behavior in Pigeons

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ABSTRACT

An experiment in which a pigeon was trained in contextual discrimination of its own behavior was carried out. When the experimental chamber was illuminated with a constant light, the pigeon had to peck on a red (or green) key in the sample component after having been pecking to the left (or to the right). When the chamber was illuminated with an intermittent light, the reinforced sample-comparison sequences were the opposite. The subject learned the task in about 40 sessions and maintained high correct response ratios even though the reinforcement probability decreased from 1 to 0.2 after each correct trial. The results are discussed in terms of the kind of discriminative rule and the kind of hierarchic structure involved in the task.

Keywords: Contextual discrimination, conditional discrimination, proprioceptive stimulus, pigeons.

RESUMEN

Se llevó a cabo un experimento en el que se entrenó a una paloma en una discriminación contextual de su propia conducta. Cuando estaba iluminada la luz general de la cámara experimental de manera constante, la paloma tenía que picar una tecla roja (o verde) tras haber estado picoteando a la izquierda (o derecha) en el componente de muestra. Cuando la luz general de la cámara se iluminaba de manera parpadeante, las secuencias reforzadas muestra-comparación fueron las contrarias. El sujeto aprendió la tarea en unas 40 sesiones y siguió manteniendo unos altos índices de acierto a pesar de bajar la probabilidad de reforzamiento tras cada ensayo correcto de 1 a 0.2. Los resultados se discuten en relación con el tipo de regla discriminativa y de estructura jerárquica involucradas en esta tarea.

Palabras Clave: discriminación contextual, discriminación condicional, estímulo propioceptivo, palomas.

In the field of Experimental Analysis of Behavior (EAB) the study of relationships between the behavior of organisms and environmental events has become increasingly complex (See Gómez, García, Pérez, Gutiérrez, & Bohórquez, 2004, for review). Starting from its subject matter (behavior) as its basic unit, it is possible to gradually add new elements:

I. In operant conditioning (Skinner, 1938), consequences (stimuli) following a response affect the probability of repetition of that response in the future.

II. However, the response-reinforcer relationship always appears in a context (See fig. 1). If any environmental characteristic correlates to the operant one on a regular basis, it will gain some control over the probability of response emission. We refer to those stimuli increasing the probability of an operant response as discriminative stimuli, whereas those stimuli decreasing the probability of an operant response are referred to as delta stimuli (Skinner, 1938, 1953).

III. The role of a stimulus as discriminative or as delta (also referred to in this work as correct or incorrect comparison) is not necessarily always the same but it may

Fecha recepción: 04/05/2007 • Fecha aceptación: 15/06/2007
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This research was partially sponsored by the projects of the Ministerio de Ciencia y Tecnología de España (SEJ2005-04633 granted to Andrés García) and (BSO2003-02182 a Santiago Benjumea) and by the project of the Junta de Andalucía (HUM-633) granted to Santiago Benjumea.

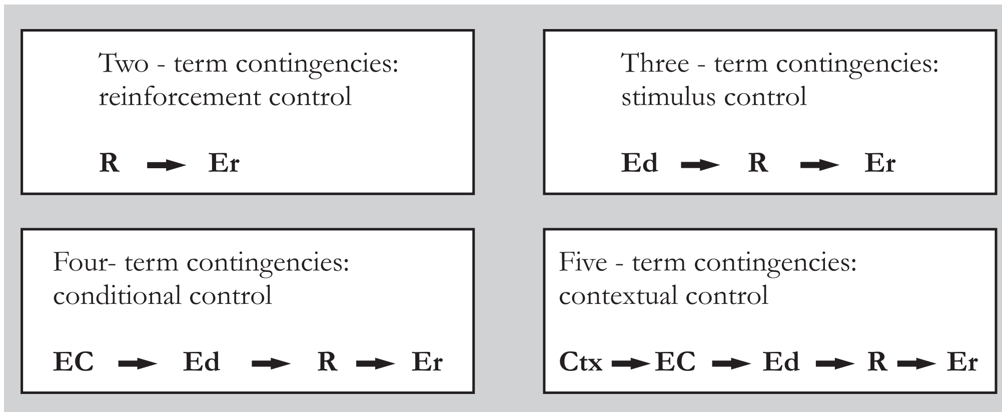

Fig.1. *Different kinds of operant contingencies according to the number of elements involved.*

vary according to the presence of other environmental events (See fig.2). Just as the discriminative stimulus makes choosing the correct two-term unit in each situation possible, the three-term unit chosen might function according to the conditional stimulus (also called sample) present in each case.

IV. It is possible to advance even more in the complexity of behavior by adding one more term to the four-term relationship described in the above paragraph. Actually, it has not yet been determined the amount of extra terms that might be effectively added (Sidman, 1994). If we work based on this, we will achieve a contextual control of the relationships from the previous level.

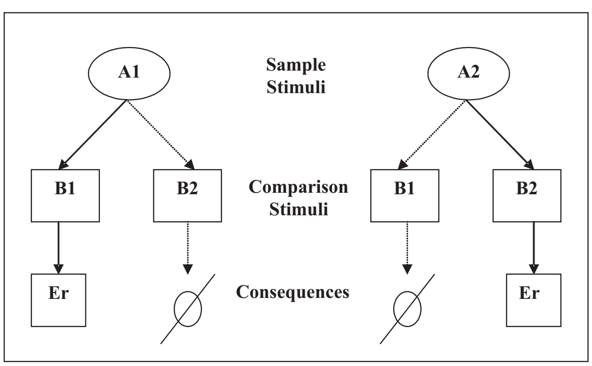

Fig.2. *Standard conditional discrimination scheme. Stimuli* **A** *are the samples indicating wich* **B** *stimulus is correct for each occasion.*

For human subjects, research on contextual control has been vast and thematically varied (Pellón, 1999; Pérez, 1994). Hence, different research has proven that derived behavior might remain under contextual control (Bush, Sidman, & De Rose, 1989; Dymond & Barnes, 1995; Kohlenberg, Hayes, & Hayes, 1991; Lynch & Green, 1991). Even relationships that are more complex like that of equivalence-equivalence might remain under contextual control as well.

Additionally, in some research lines both contextual control and verbal behavior have been studied (Paracampo, Souza, Matos, & Albuquerque, 2001; Ribes, Torres, & Ramírez, 1996; Varela & Linares, 2002). In typical experiments as those described in Bush et al. (1989), subjects are presented with two groups of conditional discriminations (Fig.3): in context X they will be trained A1–B1 and A2-B2, while in context Y relationships trained will be A1-B2 and A2–B1. The results of these experiments prove that conditional discriminations learned by subjects depend on the given context.

However, in non-human animal species, evidence of the ability to successfully learn five-term contingencies is scarce. Literature about animals on this matter has not been prolific, though we can find some studies (Bush, Sidman, & de Rose, 1989; Loy & López, 1999; Nevin & Liebold, 1966; Santi, 1978; Swartzentruber, 1993; Weigl, 1941) whose subjects have mostly been pigeons, rats, and monkeys. For instance, in Santi's experiment (1978), a group of pigeons was trained to choose the sample stimulus of the same color or of a different color (comparisons), depending on the presence of a vertical or a horizontal line (contextual stimuli).

In all of these studies, conditional discrimination remaining under contextual control was formed by samples of the exteroceptive kind (mostly visual stimuli). However, we consider that there is not any relative limitation to the nature of stimuli that can be included in this kind of settings. Consequently, sample stimuli, for example, may be of a proprioceptive nature. While there are, on one hand, some experiments researching discrimination of one's own behavior (Beninger, Kendall, & Vanderwolf, 1974; García, 2000; Lionello-DeNolf & Urcuioli, 2003; Pérez-Acosta, Benjumea, & Navarro, 2001; Reynolds & Catania, 1962; Shimp, 1982; 1983; 1984), and on the other hand, there is also literature available on contextual control (or at least on performance under five-term contingencies), we have not found, through our bibliographical review, any study combining both research lines.

	X				**X**				**Y**				**Y**	
	A1				**A2**				**A1**				**A2**	
B1		**B2**		**B1**		**B2**		**B1**		**B2**		**B1**		**B2**
+						+				+		+		

Fig.3. *Contextual discrimination.* **X** *and* **Y** *stimuli are the contextual stimuli; stimuli* **A1** *and* **A2** *are the samples, and stimuli* **B1** *and* **B2** *are the comparisons. The* **"+"** *sign indicates the reinforced combinations.*

The objective of this experiment was to carry out a contextual control training in discrimination of the own behavior in a non-human organism.

METHODS

Subject

For this experiment, a pigeon (*Columbia livia*), labeled as J-75 and kept at 75% of its original *ad libitum* weight, was used as a subject. The subject was placed in an individual home cage during non-experimental periods, in which it had free access to water. Throughout the experiment, a day-night cycle, consisting of a 12-hour light period and a 12-hour dark period, was maintained.

Devices

A Letica LI-830 standard experimental chamber for bird conditioning was used. It was placed inside a soundproof box. The soundproof box was equipped with a 40 w light bulb and an air extractor which, in order to cover any possible external noise, produced a constant noise as the experimental sessions were carried out.

The experimental chamber itself consisted of a 27 x 24 x 32 cm compartment with side panels made of metacrilate intended to allow external illumination. In the center of the frontal panel a Letica LE-200-5 bird feeder was installed and it was illuminated by a 5 w light when activated. In such occasions, the device allowed access to a grain mix through a 4, 5 x 7 cm window which opened up to 4 cm above the chamber grid floor.

On each side of the frontal panel and at about 20 cm above the floor, two Letica LE-200-5 response keys were placed. The keys were equipped with three 24 w light bulbs; the first one illuminated with a white light, the second with a red light, and the third one with a green light. A 3 cm-diameter translucent disc let these types of light in, also serving to record the animals' responses.

In addition, the light bulbs could be set to blink at a speed previously determined by the researcher. Two easily differentiable blinking speeds were used: 200 msec (quick blinking) and 800 msec (slow blinking). The number indicates the time that the light bulb remained in a state (e.g. on) before moving on to the next state (e.g. off).

The conditioning chamber was controlled by a computer running the Schedule Manager for Windows V.1.0 software. Communication between the computer and the chamber was provided by a Med Associates interface.

The equipment was complemented with a Letica LE-2000 digital balance used to control the animals' weight before and after each experimental session.

Procedure

This subject participated in a procedure in which it had to learn one discrimination and the opposite simultaneously; therefore, training started including from the beginning mixed trials of the discriminations in both contexts.

Initial training. We started doing 40 discrimination trials a day with a 4 sec. access period to the feeder. From the sixth session on we carried out 80 trials, with 3 sec. periods of access to the feeder and finally, from the eleventh session on we carried out 100 trials a day with 2 sec. periods of access to the feeder.

Each session started with a 10 second long interval between trials (ITI), where only the overall light of the chamber was on; in half of the trials it was blinking, and it was constant in the other half (contextual stimulus). This contextual stimulus remained activated during the whole trial.

Once the ITI was over, both keys in the chamber illuminated with a white light. A recurring RF10-extinction program worked on these keys. Its position was determined randomly for each trial (50% probability). When the subject completed the reasoning component, the white keys turned off leading to a 2 second interval between stimuli (ISI) during which only the overall light (constant or blinking) was on. The key pecking during ITI and ISI was submitted to a Differential Reinforcement of Other behaviors (DRO).

After the ISI, the keys illuminated randomly, one with red and the other with green, depending on their right-left position (R-G or G-R). In this situation we required 10 responses from the subject to the correct comparison in order to have access to the reinforcer, while only one incorrect response would lead to the correction procedure (see below).

If the subject manages to move on to the comparison situation in a constant context after responding "left" (fig 4), it should respond to the red comparison regardless its position. If, given this same context, the subject moved on to the comparisons by responding to the one on the right, it should respond to green regardless its position. The inverse relationship was given in the blinking context because if the subject had responded to the one on the left, now it had to choose the green comparison, and if it had responded to the one on the right it had to choose the red comparison.

Any correct response during this phase, under any condition, was reinforced with access to the feeder. If, on the contrary, the subject failed, it was submitted to a correction procedure which consisted of 10 sec. periods of time out (TO) during which every light in the chamber remained off (Ferster & Skinner, 1957). After the time out, the chamber went back to the same situation in which the subject had made the mistake. If the subject failed again, it had to go back to the TO component, but if it responded correctly, the response was reinforced. By doing so, we made sure that the pigeon got the reinforcement the same amount of times for each context, position, and color.

The execution criterion that was determined to terminate this phase was a constant number of correct responses, in all of the discriminations, equal or above 85% of the trials in each session, during five consecutive sessions (500 trials).

Decrease in reinforcement probability. Once met the above criterion, we proceeded to a gradual reduction of the reinforcement probability in each trial (Carter & Werner, 1978). From 100% reinforced trials we moved on to 90%, 75%, 50%, 30% y 20%. The criterion to switch from one condition to the next was a constant number of correct responses equal to or above 85% of the correctly responded trials in each session, for three consecutive sessions (300 trials).

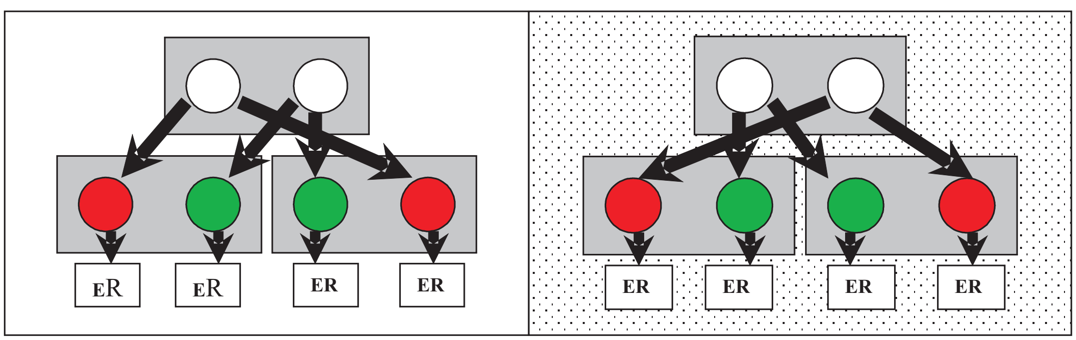

Fig.4. *Diagram of the procedure for contextual control of the own behavior. On the left, correct sequences with constant light. On the right, correct sequences with intermittent light.*

RESULTS

The subject's responses during the discriminations were at a near random level for about 20 sessions. From that moment on, its number of correct answers started to increase significantly, accomplishing the execution criterion in session 38 (fig 5, table 1). Such a criterion remained stable and even increased slightly during the 12 sessions in which the reinforcement probability was decreasing from 100% to 20%, placing the performance between a 92-97% correct response range in the last three training sessions. This evolution was very similar for both contexts (constant and blinking light). The correct response range was higher in 29 sessions (out of 53 total sessions) in the constant context; in 20 sessions in the intermittent context and in 4 sessions the correct response range was exactly the same.

DISCUSSION

The main finding of this project was the expansion of the evidence of contextual control in non-human subjects (Bush, Sidman, & de Rose, 1989; Loy & López, 1999; Nevin & Liebold, 1966; Santi, 1978; Swartzentruber, 1993; Weigl, 1941) to situations in which conditional discrimination is based on a behavior of the subject as a proprioceptive sample stimulus (Beninger, Kendall, & Vanderwolf, 1974; García, 2000; Lionello-DeNolf & Urcuioli, 2003; Reynolds & Catania, 1962; Shimp, 1982; 1983; 1984). Consequently, we can maintain that the pigeon has learned a quite complex discrimination, since it has learned a third-order stimulus control relation in which the meaning of each stimulus is conditioned by the remaining stimuli. Concerning the results of our work, we must highlight as well the relatively short time the subject took to acquire the

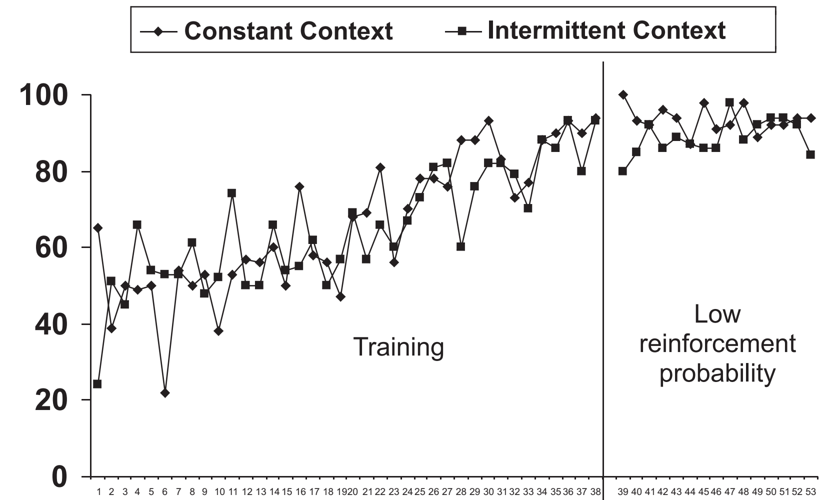

Fig.5. *Contextual control acquisition. The percentage of correct responses per session is represented on the y axis. The number of sessions is on the* **x** *axis.*

Table 1. *Pigeon J-75 results.*

Procedure	Combined discriminations	
Contextual Control	Simultaneous discrimination [context (position-color)]: 3900 trials.	Decrease in reinforcement probability: 1500 trials.

discrimination. If we consider the mean number of 3200 trials as a reference that a group of pigeons needed to learn the conditional discrimination of their own behavior in similar procedures to the one we describe here (García, 2000), we observe that, in contrast, it took very little time to learn a task that is at least twice as complex (contextual discrimination vs. conditional discrimination). In their work in 1978, Carter and Werner proved that in order to solve the typical tasks of conditional discrimination, pigeons used a set of "discriminative rules", of the "if…so" kind. (e.g.: "if *right*, then *green*", etc.). Carter and Werner showed how by doubling the number of rules of this kind contained in a task, the number of trials that the pigeons required to learn doubled as well. The short time that the pigeon needed to achieve the criterion, if we compare the four-term discrimination to the five-term one, indicates that it is probably not using this set of "if…then" rules, because according to Carter and Werner's analysis, we should expect it to take about 6000 to 6500 trials. Future research will be able to clarify the reason for this unusual quick learning pace.

Once demonstrated that subjects are able to adapt their behavior to five- term contingencies, it is necessary to determine whether their behavior is controlled by a stimulus setting or by their hierarchic structure (Griffee & Dougher, 2002). According to Arnold, Grahame and Miller (1991), some manipulations during the training phase might as well minimize control due to the stimulus setting. In Arnold et al.'s experiment (1991), the higher order *occasion setting* was researched, though with an operant design. In their procedure, stimuli were presented serially, and the probability for subjects to solve the problem in response to a unique stimulus compound was minimized through the insertion of a five second gap period between the different controlling stimuli present in each trial.

Even though the training structure has to decisively influence the strategy that the subjects adopt, we need to be careful in our inferences about the control of behaviors that we observe. Just as Bush et al. (1989), Sidman and Taliby (1982) and, even before, Carter and Werner (1978) claimed, the mere performance of the subject facing a stimulus set that the researcher perceives as hierarchic does not provide us with evidence of which stimuli are guiding its behavior. By merely observing an adequate performance we can not distinguish a behavior following a set of specific rules (or a setting strategy) from a purely conceptual behavior. For instance, if a pigeon chooses red in the presence of red and green in the presence of green, it is possible that it was the only thing the pigeon learned. In order to prove that its behavior is conceptual (that it is determined by a reflexive relationship in this case) we should verify if its behavior is still the same when it is presented with new stimuli. A proper test would be one that checks if it chooses yellow in the presence of yellow without having been reinforced for that response, which would indicate that the controlling stimulus of its behavior is the relationship between the sample and the comparison (if we keep a functional conception of what a stimulus is, we will be able to state that this relationship is the only stimulus that is maintained from one situation to the next) and not the concrete stimuli. If applying this reasoning to the five-term contingencies, to claim that the subjects' behavior is contextually controlled, we should find new behaviors under the right test conditions, just like in human subject studies. This kind of studies would help to establish the kind of hierarchic categorization that might be operating in such cases.

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