Allocation of behavior in a simple discrimination task [1, 2]

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Abstract

Eight rats responded for food in a discrete-trial discrimination procedure (Go/No-go discrimination task). The subjects' head entries to the feeder were reinforced whenever the discriminative stimuli ('Go' signal) were illuminated. Two lights located at opposite sides of the experimental chamber served as discriminative stimuli, and the 'No-go' component was signaled by a time-out (TO) of variable durations. The subjects' global responding in the discrimination task were described at different levels of analysis, as well as the distribution of other behaviors during the 'No-go' periods. Each of eight subjects learned to differentially respond to stimuli, showing short latencies from the S+ onset; nevertheless, commission errors differed among subjects. The video-recording analysis revealed that the time-allocation of other behaviors diverged among subjects. Specifically, the subjects with numerous commission errors engaged less time in alternative activities (i.e. nosing the floor) than did the subjects with less commission errors. Findings suggest that in a simple discrimination task, the allocation of activities are relevant to a comprehensive understanding of stimulus control and relative phenomena such as behavioral contrast.

Key words: *Stimulus control, Go/No-go procedure, time allocation, distribution of behavior, rats.*

Resumen

Se expuso a ocho ratas a un procedimiento de discriminación con ensayos discretos (procedimiento tipo Responder/No-responder). La respuesta blanco consistió en meter la cabeza al comedero, los estímulos discriminativos (E^D) fueron dos luces localizadas en paredes opuestas de la cámara experimental, y los componentes en extinción se identificaron por un tiempo fuera de duración variable. El desempeño de los sujetos en la tarea de discriminación fue descrito con diferentes niveles de análisis, así como la distribución de conductas durante los períodos en ausencia del E^D. Todas las ratas aprendieron a responder correctamente, mostrando latencias cortas ante la presentación del E^D. No obstante, los errores por comisión mostró variabilidad entre los sujetos. El análisis de las otras conductas que se registraron por medio de una video grabación permitió identificar dos tipos de ejecución en los sujetos: los sujetos con mayor número de errores pasaron menos tiempo en conductas alternativas como la exploración del piso respecto a los sujetos con mejor ejecución. Los hallazgos sugieren que en una tarea simple de

discriminación, la redistribución de las actividades es relevante para un mejor entendimiento del control de estímulos y fenómenos relacionados, tales como el contraste conductual.

Palabras clave: *Control de estímulo, procedimiento Responder/No-responder, distribución de tiempo, distribución de conductas, ratas.*

Stimulus control has been defined as the change in some response characteristic as a function of the change in a property of a stimulus (Rilling, 1977; Terrace, 1966). The most widely dependent variable used in stimulus-control studies is the change in rate or probability in which the target response occurs. Thus, when differential responding is found in an organism facing different stimuli, then a stimulus control is accomplished.

Much research demonstrates the importance of stimulus control as defined above in psychology (Honig & Fetterman, 1992), such as categorization (Cook & Wasserman, 2006), concept formation (Hernstein, 1990), choice (Davison & Tustin, 1978), memory (Jans & Catania, 1980; White, 2001), and perceptual processes (Fetterman, Stubbs, & MacEwen, 1992). Some research has evaluated stimulus control from a molar view in behavior analysis (Baum, 2002) considering the overall activities the subjects engaged in during the discrimination training (Rand, 1977).

From a molar perspective (Baum, 2002), stimulus control entails a change in the allocation of the organism's activities during its presence (not just turning certain responses on or off). This reallocation of behavior is induced by the contingency between the stimulus and the reinforcer. In other words, the discriminative stimulus will modulate the behavior allocation as the food is contingent to the stimulus (Baum, 2012). Because the activities of the organisms are continuous in time, the change in the occurrence of a behavior is relative to the whole activity of the subject.

Since the discriminative stimulus sets the occasion for responses to be reinforced, the criteria by which correct responding is established depends on the presence or absence of the stimulus. Table 1 shows the discrimination matrix of stimulus and response events considering only the target response. The two cases of correct performance consist of emitting target responses when the S+ is present (hits), or withhold responding when S+ is absent (or when an explicit S- occurs). The errors occur when a subject emits target responses in the absence of the stimulus (commission errors), or by withhold responding when the stimulus is present (omission error).

Table 1. Matrix of correct and incorrect responses in a simple discrimination task

		Stimulus	
		Present (+)	Absent (-)
Response	Yes	Hit	Commission error
	No	Omission Error	Correct omission

For animals, being alive is to behave (Baum, 2012), so the animals will necessarily occupy the time behaving during periods of S-, as well as in S+, engaging in behaviors others than the target one. The Table 2 shows a different picture of the analysis of such behavior allocation. Even when correct responses

and errors are considered the same as in Table 1, the Table 2 assumes a continuous stream of behavior (Schoenfeld & Farmer, 1970) within it. Table 1 dichotomizes Table 2.

The target response is only one activity among which many others could occur with a probability from 0 to 1. If the stimulus control is effective, the activities will allocate in such a way that target responses will arise when S+ is presented (correct responses in Table 1), and alternative behaviors will occur in its absence.

Table 2. The continuous stream of behavior inserted in discrimination matrix

	Stimulus	
	Present (+)	Absent (-)
Activities From 0 to 1.0	Continuous behavior stream (systematic changes in allocation of behavior)	

Considered together, Tables 1 and 2 suggest that the occurrence of target responses are relative to the whole activity of the subject; since subjects are continuously behaving during discriminative stimulus training, a change in behaviors other than the target response will occur.

With the argument that during stimulus control the target response is relative to the whole activity of the animal, Rand (1977) recorded pigeons' activities in a simple discrimination learning task. She found that pigeons spent a high proportion of the time pecking at the key during the S+ (stimulus associated with food), but the subjects engaged in stereotyped behaviors others than key pecking during the S- (stimulus associated with extinction). Accordingly to other studies, Rand (1977) found that during the S-, some behaviors that she named 'timeout behaviors', showed that pigeons removed the visual stimulus from view by moving so that "both eyes of the bird being located in the areas of low illumination" (p. 106). These timeout behaviors have been observed as emotional responses, by turning away from the key during the S- presentation (Terrace, 1966), or by responding to turn off the S- for a while (Rilling, Askew, Ahlskog, & Kramer, 1969; Terrace, 1971).

Most of the procedures that have measured activity (Killeen, 1979) or have observed the subjects' behavior within the operant chambers concerns to timing and periodic food delivery (Innis, Simmelhag & Staddon, 1983; Killeen, 1975; Killeen & Fetterman, 1988; Reid, Vazquez & Rico, 1985), superstition (Staddon & Simmelhag, 1971), autoshaping (Stokes & Balsam, 1991), etc., but a few of them concerns to stimulus control (Rand, 1977).

Although the periodic-reinforcement performance is tied to the discrimination of time (Skinner, 1938), stimulus-discrimination procedures have focused on differential target responding to S+ (key pecks or pressing a lever), but have neglected the distribution of other behaviors. If interim and facultative behaviors (Staddon, 1977) are important for a behavioral account for time discrimination (Killeen, 1975), it can be equally relevant to analyze the distribution of other behaviors in the repertoire of the organism to understand phenomena such as stimulus control and behavioral contrast (Haight & Killeen, 1991; Killeen, in press).

Based on the assumption that animals allocate behavior as the result of induction by food and discriminative stimuli (see Baum, 2012), the present experiment examined the change in the behavior allocation of rats during the acquisition of the stimulus control in a Go/No-go procedure (Neill &

Harrison, 1987). If the probability of emitting the target response (Go) increases during the stimulus control acquisition, the present study analyzed whether a different behavioral pattern emerged orderly when S+ is absent (No-go).

Method

Subjects

Eight naive male Wistar rats (numbered R01 to R08) of approximately 4-month-old at the beginning of the experiment participated as subjects. The rats were obtained from the breeding colony of the Neuroscience Institute of the University of Guadalajara. Rats were housed individually in clear transparent cages (30 x 15 x 20 cm) with free access to water, and maintained on a 12-hr/12-hr light /dark schedule, with dawn approximately at 9 h. A food deprivation regimen maintained the rats at 85% of their free-feeding weights.

Apparatus

Two MED operant chambers for rats (ENV-007-VP, 30 x 24.5 x 30 cm) were used. Both chambers were equipped with two feeders (apertures 5-cm wide, 5-cm high, 3-cm deep) located 2 cm above the floor at the center of both, left and right panels. Feeders were equipped with head-entry detectors (ENV-254-CB), and delivered 45 mg of amaranth (*Amarantus cruentus*) as reinforcer (see Cabrera, Robayo-Castro & Covarrubias, 2010). A circular light (28-V, 100-mA, 2.5 cm in diameter) was located 2 cm above each feeder aperture. A source of white noise (73 dB) was located outside the chamber behind the left panel. To visually isolate the cages from the lab room, wooden walls were built and mounted around the chamber. A computer controlled stimuli and registered responses through a MED interface. Sessions were video recorded by a camera located on the top, outside of the operant chambers.

Procedure

On the first day of the study, each rat was exposed to the Go/No-go procedure. Since the target response was too easy to emit (i.e. head entry to feeder aperture), no previous training was necessary. Rats obtained amaranth in the operant chamber only if they entered their head into the feeder when the corresponding stimulus was lit. If rats entered the head in the opposite feeder, the stimulus turned off, but no food was delivered. Likewise, if rats entered the head when light was turned off, no food was delivered, and the time counter was reset. In the correct responses, the first head entry delivered food, the light was turned off and the time counter was reset. After each head entry to the feeder, being correct or incorrect, the time counter was reset to zero, and the program randomly selected a inter-trial time (ITI) among 20, 25, or 30 seconds to the onset of the next S+ presentation; the ITI value was randomly assigned to the left or the right stimulus. With this procedure, the stimulus lit above each feeder served as the discriminative stimulus (S+) or the 'Go' signal, and the lights turned off during the ITI were equivalent to the delta stimulus (S-) or the 'No-go' signal.

All subjects were exposed to the discrimination task for 12 consecutive sessions, each session having a duration of 45 min. After each session, rats were returned to the home cages, and received complementary food to maintain the weight.

Video recording analysis

Four subjects were selected for video-recording analysis. Two näive independent observers watched and registered the behaviors using CowLog (Hänninen & Pastell, 2009), producing a behavioral

ethogram with seven mutually exclusive categories: Head entry, noosing the floor, locomotion, fore-paw exploration, turning over, rearing and grooming. These behaviors are described in Table 3. For each behavior category there was analyzed the proportion of time in each behavior and the proportion of within-trial distribution of behavior at different periods of the Go/No-go trials. Criteria for reliability was above 80% of interobserver agreement.

Table 3: Description of coded behaviors.

Behavior	Description
Head entry	Entering the head into or around the feeders.
Nosing the floor	Standing 4-paws on the floor, sniffing, licking, or nibbling the rods of the floor.
Locomotion	Moving from one place to another in the chamber without noosing the floor.
Fore-paw exploration	Standing 4-paws on the floor with the head upright, or noosing the walls (not the floor).
Turning over	Turn the head over followed by turning the body to other direction.
Rearing	Lifting onto the hind legs exploring the top side of the box, without grooming movements.
Grooming	Sniffing and leaning himself.

Results

Figure 1 shows the proportion of correct responses (head entries) through sessions of the discrimination procedure. Each rat corresponds to a symbol and the continuous line represents the average. In the first session all rats responded randomly to the presence or absence of S+, with a proportion around 0.5. Correct responses increased noticeably from the third to the fifth session, and then increased slightly until the eighth session. After that, a stable average close to 1.0 is observed for all subjects (except R04 in session nine that felt below of 0.9).

Figure 1. Proportion of correct responses to S+ through sessions. The symbols represent different subjects and the continuous line represent the average.
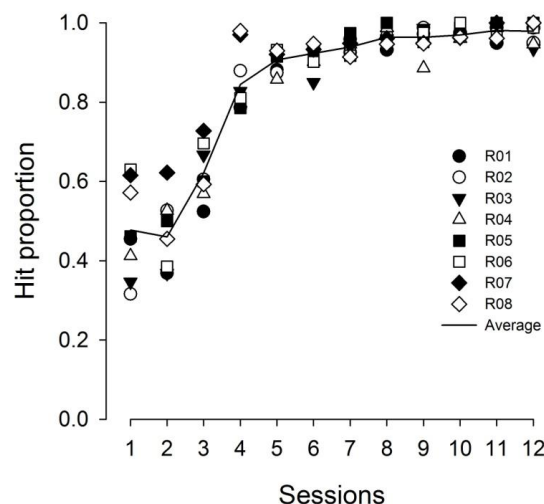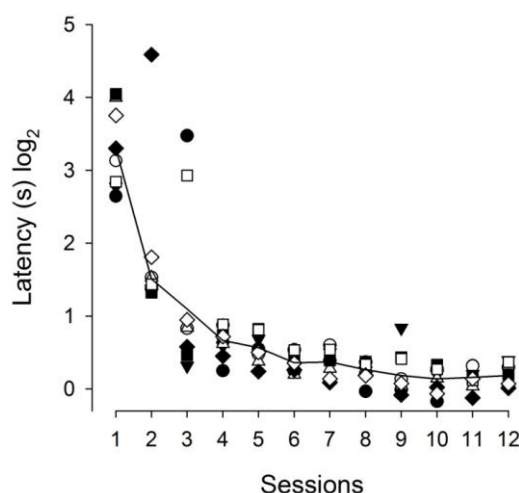
Figure 2: Latency of correct responses since the S+ onset plotted against successive sessions. Note that in order to enhance differences among subjects, a base-2 logarithm was used.

The latency of correct responses, or reaction time since the S+ onset, is shown in Figure 2 across sessions (note the y-axis base-2 logarithm). At the first session, subjects had latencies from 7 to 16 seconds. After Session 2 all subjects dropped to 3 s latencies, with the exception of R07 (filled rhombi) that showed latencies of 30 s. From the third to the seventh session, all rats decreased slightly the latencies to values close to 1 s. Finally, from the eight session to the end, with the exception of R03 (filled triangles), all subjects showed a steady state close to 1 s.

The proportion of commission errors through sessions are shown in Figure 3. This dependent variable consists in the number of head entries to the feeder at the 'No-go' periods when S+ was absent, relative to the total number of S+ presentations. Except for the increase in the second session, the errors decreased orderly across sessions from 10 errors to 0.5 in average per 'No-go' period (note the y-axis base-2 logarithm). However, from the eight to the last session subjects R02, R05, and R06 (open circles, filled squares, and open squares, respectively) descended until close to 0.12 errors per 'No-go' period.

Figure 3: Proportion of commission errors plotted against successive sessions. Note that in order to enhance differences among subjects, a base-2 logarithm was used.
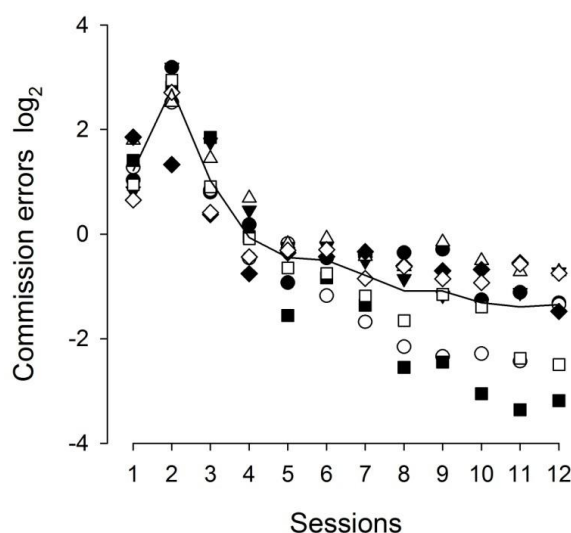
As a consequence of the commission errors shown in Figure 3, the timer that scheduled the next S+ was reset to 0 (see procedure section). Hence the interval to the next trial increased and the total number of opportunities to obtain food decreased. Table 4 shows the percent of S+ (opportunities to eat) presented to each subject and the percentage of obtained food. The more efficient rats were R02, R05, and R06 that obtained more than 90% of the S+ and food scheduled. In contrast, rats R01, R03, R04, and R07 got less than 90% in the two variables.

Table 4: The percentage of total S+ presented to each subject, and the percentage of obtained food in the last five sessions.

Subject	%S+ Presented	%Food obtained
R01	86	83
R02	94	91
R03	86	83
R04	83	79
R05	96	95
R06	93	91
R07	89	86
R08	90	86

With the purpose to observe whether subjects with better performance (rats R02 and R05) exhibited different distribution of behaviors than those subjects with poorer performance (rats R01and R04), the coded behaviors described in Table 3 were used to compare the global allocation of activities among those subjects. Figure 4 shows the global allocation of time within a session (45 min) for the subjects with the highest performance (upper panels) and two subjects with low performance (bottom panels). The pie graphs show that rats R02 and R05 spent less time with the head close or into the feeder than the rats with lower performance (about 10% more time). In addition, the rats with better performance spent similar times nosing the floor than entering the head into the feeder; in contrast, the rats with lower performance spent substantially less time nosing the floor (about 30%) than entering the head into the feeder (more than 50%). Minor differences were observed in other behaviors such as rearing, grooming, fore-paws exploration, etc.

Moving into a more local analysis of the distribution of behaviors, Figure 5 shows the allocation of activities within a trial, using 10 s time-windows from the S+ onset to a maximum of 50 s. Upper panels show the rats with better performance (R02 and R05), and bottom panels show rats with low performance (R01 and R04). For all subjects, the proportion of the head entry was the more frequent activity at the beginning the S+ (proportion of 0.5), falling abruptly to low levels after 20 s elapsed (the exception was R04 whose decline was more gradual). The locomotion and turning over had proportions close to 0.25 in the first 10 s. Nosing the floor was substantially increased after the 20 s, rising from 0 in the first 10 s since the S+ onset, to values close to 0.5 (rats R01 and R02), 0.6 (R04), and 0.8 (R05). For the subjects R02 and R04 this behavior was maintained through the time over the others behaviors, but subjects R01 and R05 felt below others behaviors at the end of the interval. Rearing was the following more frequent behavior, increasing through the time, to a proportion around 0.4, with the exception of rat R01 that distributed the activities among fore-paws exploration, turning over, and locomotion.

Figure 4: Time allocation for different activities for four subjects within a session (average of sessions 10 and 11). See main text for further details.
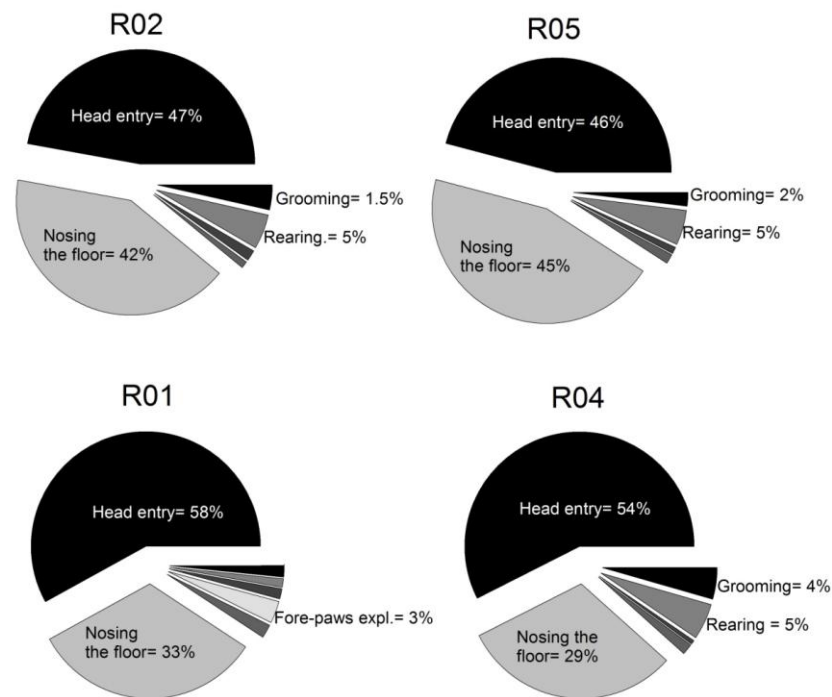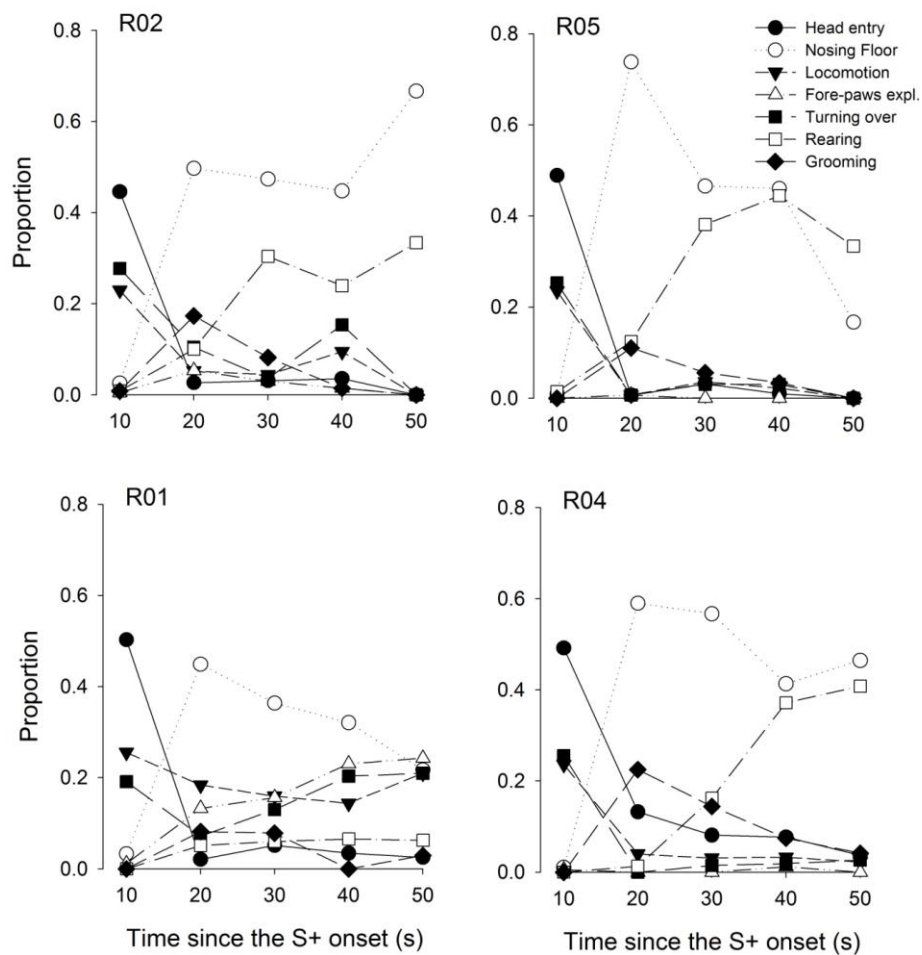

Figure 5: Within-trial temporal distribution of behaviors plotted over 10-sec intervals since the S+ onset.

The rats' more frequent behaviors were head entries and nosing the floor (figures 5 and 6). Since the discrimination training involves changes in behavior allocation, it is assumed that the probability in which overall behaviors occur will change during acquisition. Figure 6 shows the average proportion of the more frequent behaviors at three different stages of the training (different symbols), as a function of the time since the S+ onset. Filled symbols represent nosing the floor and open symbols represent head entries. Circles, triangles, and squares correspond to the early, middle and last stages of discrimination acquisition. On early stages of training, both activities, nosing the floor and head entries (filled and open circles), in general, showed similar values along the interval, with more variability at the first 10 s. At the middle stages (triangles) the proportion of behaviors diverged each other; nosing the floor tended to increase through the interval, and head entries decreased in all subjects. Finally, at the last stage of the discrimination training (squares), nosing the floor was notoriously more frequent than the head entries.

Figure 6: Within-trial temporal distribution of nosing the floor (filled symbols), and head entries (open symbols) behaviors, plotted over 10-sec intervals since the S+ onset. Different profiles correspond to the average of two sessions: Early (sessions 1 & 2), Middle (sessions 3 & 4), and Last (10 & 11 sessions).
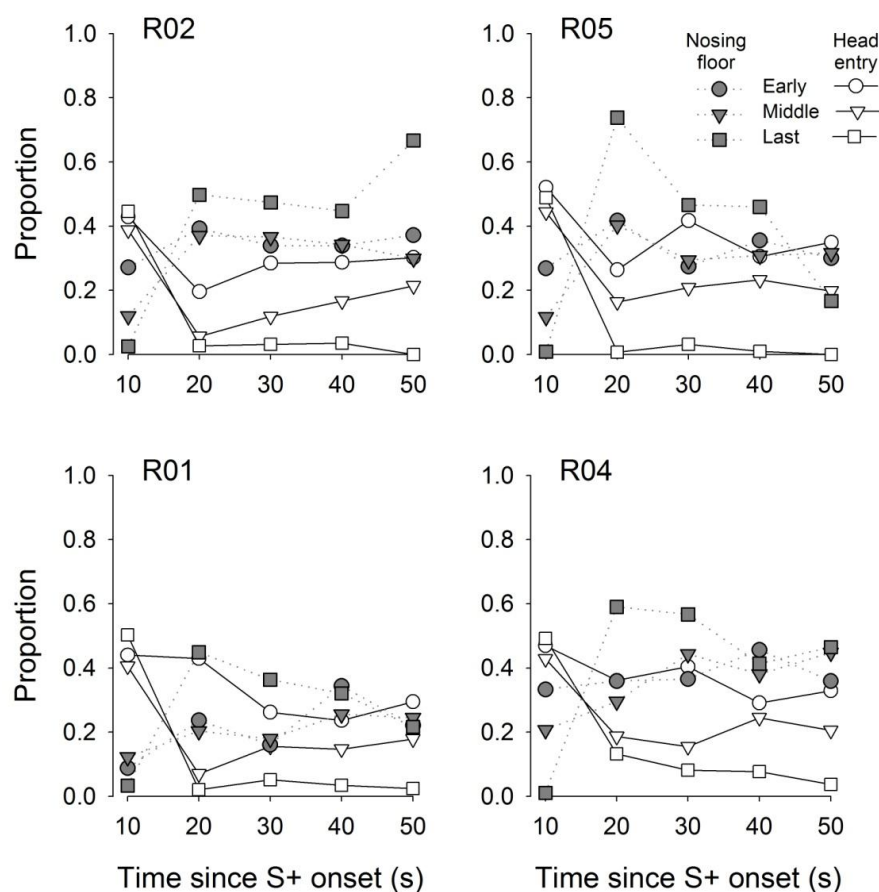
Discussion

This study extended the Rand (1977)'s findings that when an organism is not engaging in target responses during discrimination procedures, others highly vigorous activities are occurring. The Go/No-go procedure used in this experiment allowed to evaluate the distribution of behaviors at different levels of analysis.

Stimulus control can be adequately represented by the differential responding of target responses at S+ and withhold responding in the absence of S+. Nevertheless, the findings of the present experiment

suggested that for a behavioral account of response inhibition in the Go/No-go procedure, it is necessary to analyze the distribution of the activities in which the subjects engage.

If we define the response inhibition as "the suppression of actions that are inappropriate in a given context and that interfere with goal-driven behavior" (Mostofsky & Simmonds, 2008, p. 751), in a discrimination task the organism is selecting to engage or withhold responses depending on the presence/absence of appropriate context. Experimental evidence shows that in Go/No-go tasks, commission errors are linked with lack of inhibitory performance; subjects have to switch from execute a response (Go) to inhibit that response when the discriminative context is changed (Simmonds, Pekar & Mostofsky, 2008). This finding was observed in our experiment; rats inhibited the head entries to the feeder during No-go periods as discriminative training progressed (Figure 6); however, other behaviors (nosing the floor and rearing) increased.

In the present experiment, 'nosing the floor' was the most frequent behavior, other than the target response (Figure 4), and it occurred with a high proportion during the 'No-go' periods (figures 5 and 7). One possible account for why this behavior was developed is because of the tendency of emotional or agonistic behavior regards to the S- (Rand, 1977; Rilling et al., 1969; Terrace, 1971). Since no explicit S+ was used in this experiment, we should suppose that nosing the floor avoided the absence of the light (S+), or that it was an emotional response to the absence of S+. An alternative explanation comes from the resemblance of nosing the floor to the topography of the consummatory behavior. In a process similar to the form of the autoshaped-responding (Jenkins & Moore, 1973), the behavior that emerged during the 'No-go' period could be associated with the consummatory behavior. This possibility is based in that often nosing the floor included licking the rods of the floor, and eating the amaranth requires the rats repeatedly to lick the feeder (Cabrera et al., 2010) because of its size and texture. Then, given the similitude between licking the floor and consuming the amaranth, rats could have developed a stereotyped behavior close to the consummatory behavior.

The Go/No-go procedure resembled periodic schedules due to the regularity of the periods without food following each signaled period of food (Staddon, 1977). Even though the No-go periods were variable, the present data showed an analog to the schedule induced behaviors typically observed in periodic food delivery (Roca, 2011); some behavioral patterns observed during the Go/No-go trials can be understood as interim or facultative activities. The two more frequent behaviors (aside from the target response) were 'nosing the floor' and 'rearing'. On one hand, the excessive frequency of the nosing the floor as well as its early occurrence within the interval resembled the interim activities in periodic schedules (Reid, et al., 1985). On the other hand, the lower frequency of 'rearing' as well as its latter occurrence within the interval relative to nosing the floor (see figures 4 and 5) suggests the possibility that rearing had a function equivalent to the facultative behavior (see Staddon, 1977).

Aside from the issues discussed above, an important finding was that subjects that had a better performance (i.e., fewer commission errors, Figure 3) in the discrimination task, assigned more time to nosing the floor, than did the rats with poor performance. If that behavior facilitated the discrimination performance, particularly the inhibition of target responses during the No-go periods, have to be demonstrated. However, aside from the commission errors, no substantial differences were observed in correct responses (hits, Figure 1) and latencies (Figure 2) among subjects. Hence, it is possible that activities that appeared lately within the interval, such as rearing for rats R02, R04, and R05, or fore-paws exploration for rat R01, could serve as observing behaviors to make visual contact with the S+. Our finding of the emergence and distribution of other behaviors that substituted the target response during the 'No-go' periods is similar to those findings of response-sequences learning procedures, where a

particular pattern of responding is reinforced but some non-reinforced sequences concurrently emerge (Alonso, Martínez & Bachá, 2014; Bachá, Reid & Mendoza, 2007).

One potential limitation of the current experiment is that we did not use a control condition with a random presentation between light and food. This condition could discard the possibility that a sensitization or habituation effect to stimuli were responsible of the current behavioral allocation. It is possible that the learned irrelevance given the random presentations between stimulus and reinforcement (Wasserman & Miller, 1997) could develop a similar organization of the behavioral patterns. Further research is needed to examine the role of the behavior reallocation in stimulus control procedures and related issues, such as performance in periodic schedules (Staddon, 1977), and behavioral contrast in multiple schedules of reinforcement (Reynolds, 1961) where target responses could compete or interact with other behavioral patterns (Killeen, in press).

References

Alonso, I., Martínez, H., & Bachá, G. (2014). Adquisición y extinción de respuestas discretas vs. Secuencias de respuesta. *Conductual, 2*, 44-56.

Bachá, G., Reid, A., & Mendoza, A. (2007). Resurgence of integrated behavioral units. *Journal of the Experimental Analysis of Behavior, 87*, 5-24.

Baum, W.M. (2002). From molecular to molar: A paradigm shift in behavior analysis. *Journal of the Experimental Analysis of Behavior, 75*, 95-116.

Baum, W.M. (2012). Rethinking reinforcement: Allocation, induction, and contingency. *Journal of the Experimental Analysis of Behavior, 97*, 101-124.

Cabrera, F., Robayo-Castro, B., & Covarrubias, P. (2010). The 'Huautli' alternative: Amaranth as reinforcer in operant procedures. *Mexican Journal of Behavior Analysis, 36*, 71-91.

Cook, R. G., & Wasserman, E. A. (2006). Relational discrimination learning in pigeons. In E.A. Wasserman & T.R. Zentall (Eds.), *Comparative cognition. Experimental explorations of animal intelligence* (pp. 307-324). New York: Oxford University Press.

Davison, M. C., & Tustin, R. D. (1978). The relation between the generalized matching law and signal-detection theory. *Journal of the Experimental Analysis of Behavior, 29*, 331-336.

Fetterman, J.G., Stubbs, D.A., & MacEwan, D. (1992). The perception of extended stimulus. In W.K. Honig & J.G. Fetterman (Eds.), *Cognitive aspects of stimulus control* (pp. 1-20) New Jersey: Lawrence Erlbaum Associates

Haight, P. A., & Killeen, P.R. (1991). Adjunctive behavior in multiple schedules of reinforcement. *Animal Learning and Behavior, 19*, 257-263.

Hänninen, L., & Pastell, M. (2009). CowLog: Open source software for coding behaviors from digital video. *Behavior Research Methods, 41*, 472-476.

Herrnstein, R.J. (1990). Levels of stimulus control: A functional approach. *Cognition, 37*, 133-166.

Honig, W.K., & Fetterman, J.G. (1992). *Cognitive aspects of stimulus control.* New Jersey: Laurence Erlbaum Associates.

Innis, N.K., Simmelhag-Grant, V.L., & Staddon, J.E.R. (1983). Behavior induced by periodic food delivery: The effects of interfood interval. *Journal of the Experimental Analysis of Behavior, 39*, 309-322.

Jans, J.E., & Catania, A.C. (1980). Short-term remembering of discriminative stimuli in pigeons. *Journal of the Experimental Analysis of Behavior, 34*, 177-183.

Jenkins, H.M., & Moore, B.R. (1973). The form of the auto-shaped response with food or water reinforcers. *Journal of the Experimental Analysis of Behavior, 20*, 163-181.

Killeen, P.R. (1975). On temporal control of behavior. *Psychological Review, 82*, 89-115.

Killeen, P.R. (1979). Arousal: its genesis, modulation, and extinction. In M.D. Zeiler & P. Harzem (Eds.), *Advances in Analysis of Behaviour Vol. 1: Reinforcement and the organization of behaviour* (pp. 31-78). New York: John Wiley & Sons.

Killeen, P.R. (In press). A theory of behavioral contrast. *Journal of the Experimental Analysis of Behavior*.

Killen, P.R. & Fetterman, J. G. (1988). A behavioral theory of timing. *Psychological Review, 95*, 274-295.

Mostofsky, S.H., & Simmonds, D.J. (2008). Response inhibition and response selection: two sides of the same coin. *Journal of Cognitive Neuroscience, 20*, 751-761.

Neill, J.C., & Harrison, J.M. (1987). Auditory discrimination: The Konorski quality-location effect. *Journal of the Experimental Analysis of Behavior, 48*, 81-95.

Rand, J.F. (1977). Behaviors observed during S- in a simple discrimination learning task. *Journal of the Experimental Analysis of Behavior, 25*, 103-117.

Reid, A.K., Vazquez, P.P., & Rico, J.A. (1985). Schedule induction and the temporal distributions of adjuntive behavior on periodic water schedules. *Animal Learning and Behavior, 13*, 321-326.

Reynolds, G.S. (1961). Behavioral contrast. *Journal of the Experimental Analysis of Behavior, 4*, 57-71.

Rilling, M. (1977). Stimulus control and inhibitory processes. In W.K. Honig & J.E.R. Staddon (Eds.), *Handbook of operant behavior* (pp. 432-480). New Jersey: Prentice Hall.

Rilling, M., Askew, H.R., Ahlskog, J.E., & Kramer, T.J. (1969). Aversive properties of the negative stimulus in a successive discrimination. *Journal of the Experimental Analysis of Behavior, 12*, 917-932.

Roca, A. (2011). Un análisis funcional de las conductas inducidas por el programa de reforzamiento. In. H. Martínez., J.J. Irigoyen, F. Cabrera, J. Varela, P. Covarrubias & A. Jiménez (Eds), *Estudios sobre comportamiento y aplicaciones Vol. II* (pp. 21-54). México: Universidad de Guadalajara

Schoenfeld, W. N., & Farmer, J. (1970). Reinforcement schedules and the "Behavior stream". In W.N. Schoenfeld (Ed,). *The theory of reinforcement schedules* (pp. 215-245). New York: Appleton-Century Crofts.

Simmonds, D.J., Pekar, J.J., & Mostofsky, S-H- (2008). Meta-analysis of Go/No-go tasks demonstrating that fMRI activation associated with response inhibition is task-dependent. *Neuropsychologia, 46*, 224-232.

Skinner, B.F. (1938). *Behavior of organisms*. New York: Appleton-Century Crofts.

Staddon, J.E.R. (1977). Schedule-induced behavior. In W.K. Honig & J.E.R. Staddon (Eds.), *Handbook of operant behavior* (pp. 125-152). New Jersey: Prentice Hall.

Staddon, J.E.R., & Simmelhag, V. (1971). The "superstition" experiment: A re-examination of its implications for the principles of adaptive behavior. *Psychological Review, 78*, 3-43.

Stokes, P.D., & Balsam, P.D. (1991). Effects of reinforcing preselected approximations on the topography of the rat's bar press. *Journal of the Experimental Analysis of Behavior, 55*, 213-231.

Terrace, H. S. (1966). Stimulus control. In W.K. Honig (Ed.), *Operant behavior: areas of research and application* (pp. 271-344). New York: Appleton-Century-Crofts

Terrace, H.S. (1971). Escape from S-. *Learning and Motivation, 2*, 148-163.

Wasserman, E.A., & Miller, R.R. (1997). What's elementary about associative learning? *Annual Review of Psychology, 48*, 537-607.

White, K.G. (2001). Forgetting functions. *Animal Learning and Behavior, 29*, 193-207.