TRAVEL, SENSITIVITY TO REINFORCEMENT, AND MULTIPLE ALTERNATIVES

DESLOCAMENTO, SENSIBILIDADE AO REFORÇO E MÚLTIPLAS ALTERNATIVAS

Felipe Cabrera, and Carlos F. Aparicio
UNIVERSITY OF GUADALAJARA, MÉXICO

RESUMO

Quando ratos procuram por alimento em oito alternatives disponíveis concorrentemente e saltam barreiras para se deslocar de um local para outro, as distribuições de tempo e respostas geralmente ficam aquém das distribuições de reforços. Esse resultado pode refletir a maneira pela qual as barreiras são introduzidas na situação. O presente experimento explorou essa possibilidade com ratos. Esquemas concorrentes de reforço com components de intervalo randômico de diferentes durações forneceram alimento em oito barras instaladas em quatro câmaras experimentais conectadas a uma plataforma central. Primeiro, os ratos podiam entrar nas câmaras e mudar de uma barra para a outra sem restrições. Depois, o acesso às câmaras foi obstruído e as barras foram separadas uma da outra por barreiras de 300 mm de altura. Finalmente, as oito barreiras aumentaram de 300 para 700 mm. Os tempos de visita e de mudança e a quantidade de respostas de mudança foram menores quando os ratos visitavam as barras sem restrições. Com a introdução das barreiras, essas medidas aumentaram, atingindo os maiores valores quando a altura das barreiras aumentou. Para as respostas, a sensibilidade ao reforçamento, estimada pelo parâmetro s da lei generalizada da igualação, aumentou com aumentos no requisito para o deslocamento, indicando uma tendência à super-igualação. No entanto, apenas um rato mostrou a mesma tendência para a alocação de tempo.

Palavras-chave: Escolha, múltiplas alternativas, deslocamento, sensibilidade, ratos

ABSTRACT

When rats search for food in eight alternatives concurrently available and climb barriers to travel from one site to another, the distributions of times and responses often lag behind those of the reinforcers. This result may reflect the way in which the barriers are introduced into the situation. The present experiment explored this possibility with rats. Concurrent schedules of reinforcement with random interval components of different values provided food in eight levers mounted in four chambers connected to a central platform. First, the rats were allowed to enter the chambers and switch from one lever to another without restrictions. Then access to the chambers was obstructed and the levers separated from one another by 300-mm-high barriers. Finally, the height of the barriers was increased from 300 to 700 mm. The shortest visit times, giving-up times, and giving-up responses were produced when rats visited the levers without restrictions. With the barriers in place these measures increased, reaching higher values when barrier height was increased. For responses, sensitivity to reinforcement, as estimated by the parameter s of the generalized matching law, increased with increasing travel requirement, indicating a tendency toward overmatching. However, for time allocation only one rat showed the same tendency.

Key words: Choice, multiple alternatives, travel, sensitivity, rats

Research has shown that travel requirements affect behavior allocation (Baum, 1982) and time allocation (Baum & Rachlin, 1969). In studies of choice with pigeons as subjects, travel has been modeled by delaying reinforcement to the first response in one key after switching from the other key (Catania, 1966; Herrnstein, 1961). This contingency, called the changeover delay (COD), increases preference for one alternative over the other and reduces the rate of changeovers (Shull & Pliskoff, 1967; Stubbs & Pliskoff, 1969).

Preference is accurately estimated by the generalized matching law (Baum, 1974) as follows:

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$$\log\left(\frac{B_1}{B_2}\right) = s \cdot \log\left(\frac{r_1}{r_2}\right) + \log b \qquad (1)$$

where B_1 and B_2 are behavior allocations, measured in time or responses, to Alternatives 1 and 2, r_1 and r_2 are reinforcer rates obtained from Alternatives 1 and 2, *b* is a measure of bias toward one alternative or the other arising from factors other than r1 and r_2, and *s* is sensitivity of the behavior ratio to the reinforcer ratio (Baum, 1974).

In studies of choice where no COD was used (Herrnstein, 1961), or when the COD was of short duration (Brownstein & Pliskoff, 1968), the parameter *s* resulted in a value of less than 1.0, an effect that Baum (1974) called undermatching. But, when the time of the CODs has been excluded from computations of response rates (Baum, 1974), or when the responses during the COD were not counted to compute response rates (Silberberg & Fantino, 1970), the value of the parameter *s* was greater than 1.0, indicating overmatching.

The validity of the COD as a travel requirement may be questioned, because it does not require locomotion: the organism "travels" by staying in the same spot, waiting for one response to be reinforced. To address this criticism, researchers have designed some more costly travel requirements, such as pecking a key or pressing a lever to complete a fixed ratio requirement (e.g., Baum, 1976; Norman & McSweeney, 1978; Stubbs & Pliskoff, 1969; Todorov, Acuña, & Falcon, 1982), punishing changeovers with electric shocks (Todorov, 1971) or with blackouts (Silberberg & Fantino, 1970), and modifying the operant chamber to incorporate actual locomotion (Aparicio, 2001; Aparicio & Baum, 1997; Baum, 1982; Boelens & Kop, 1983; Krebs, Kacelnik, & Taylor, 1978; Ydenberg; 1984).

Although some data (Baum, 1982) suggest that in choice situations the effects of locomotion to travel resemble those of travel simulated with operant responses, the functional equivalence between COD procedures and travel requirements has been confirmed (Aparicio & Baum, 1997), and further studies were conducted in situations resembling naturalistic scenarios of foraging behavior. For example, Aparicio (2001) modified the standard choice situation by placing a barrier between two levers that provided food according to various concurrent schedules of reinforcement with variable interval components of different values; to travel between levers rats climbed over the barrier. With a barrier height of 300.5 mm the results indicated perfect matching (the slope of the generalized matching law was 1.0). But when the height of the barrier was increased from 300.5 to 450.7 mm, *s* was above 1.2 showing that sensitivity to reinforcement increased with increasing barrier height (Aparicio, 2001).

In a more refined attempt to manipulate travel and the complexity of the choice situation, Aparicio & Cabrera (2001) utilized barriers of 700 mm height to separate two, four, or eight levers. For two- and four-lever conditions, their results indicated overmatching for responses and time allocation; in both cases the slope of the generalized matching law was above 1.0. When the number of levers increased from four to eight levers, for response distributions only one rat showed overmatching (the slope was 1.10), whereas the other three rats produced slopes below 1.0, indicating undermatching. For time allocation, three out of four rats showed slopes above 1.2, indicating overmatching.

These contradictory results (undermatching vs. overmatching) with eight levers (Aparicio & Cabrera, 2001) may have arisen from the way in which the travel requirement was introduced into the choice situation: there was no condition without barriers, and the height of the barriers was not increased gradually across phases. The present study explored this possibility by starting with a baseline condition in which neither a COD contingency nor barriers were used to separate the eight levers that were concurrently available.

METHOD

Subjects

Five naive male Wistar rats (R1, R3, R5, R7 and R8) of approximately 90 days at the beginning of the experiment, participated as subjects. The rats weighted between 300 and 320 g before food deprivation and were maintained at 85% of their free-feeding weights. Water was available in their home cages where a 12:12 light / dark cycle was maintained.

Apparatus

The apparatus was similar to that used in previous studies (Aparicio, 1998, 1999, 2001). Figure 1 shows a diagram of this apparatus, which consisted of four chambers attached with nuts and bolts to a central platform measuring 380 x 380 mm. Thus, the chambers took the shape of a cross measuring 1120 square mm. Two retractable levers (MED ENV-112), operated by a force of 0.2 N, were mounted on the front wall of each chamber. Barriers of 300, or 700 mm height could be placed at the entrance of each chamber and between any pair of levers. In some conditions, the rats had to climb over the barriers to travel from one lever to another and from one chamber to another. An aperture, 830 mm wide and 50 mm high, located at the front wall and at the bottom of the barrier separating the levers, allowed rats to collect food (45-mg Research Diets Formula A pellets) from either side of each chamber. Eight 24-V DC stimuli lights, centered 40 mm above the levers and 170 mm above the floor, provided ambient illumination. Daily sessions were conducted in a lighted room, measuring 3,200 x 2,500 mm; the apparatus was placed and isolated from the rest of the equipment by a black curtain (measuring 2,200 x 3,200 mm) located at 1,300 mm from the posterior wall. Scheduling and recording of all experimental events were accomplished by using a personal computer (Dell 386-16x) and software programmed in Turbo Pascal®. Communication between the computer and the experimental chambers was accomplished by an interface (Life Science) connected to two relay boards (John Bell electronics).

Procedure

The behavior of pressing the levers for food was acquired by arranging continuous schedules of reinforcement in all levers. No barriers were used to obstruct the access to the chambers or to separate the levers. These schedules remained in effect until the rats pressed all levers within the same session, earning a total of 60 food pellets (15 for each pair of levers placed in each chamber). Then the experiment began. All sessions started by placing a rat in the center of the box (the choice point) with all levers inserted into the chambers, and the lights above them turned on. Pressing the levers produced food according to concurrent schedules of reinforcement with eight random interval

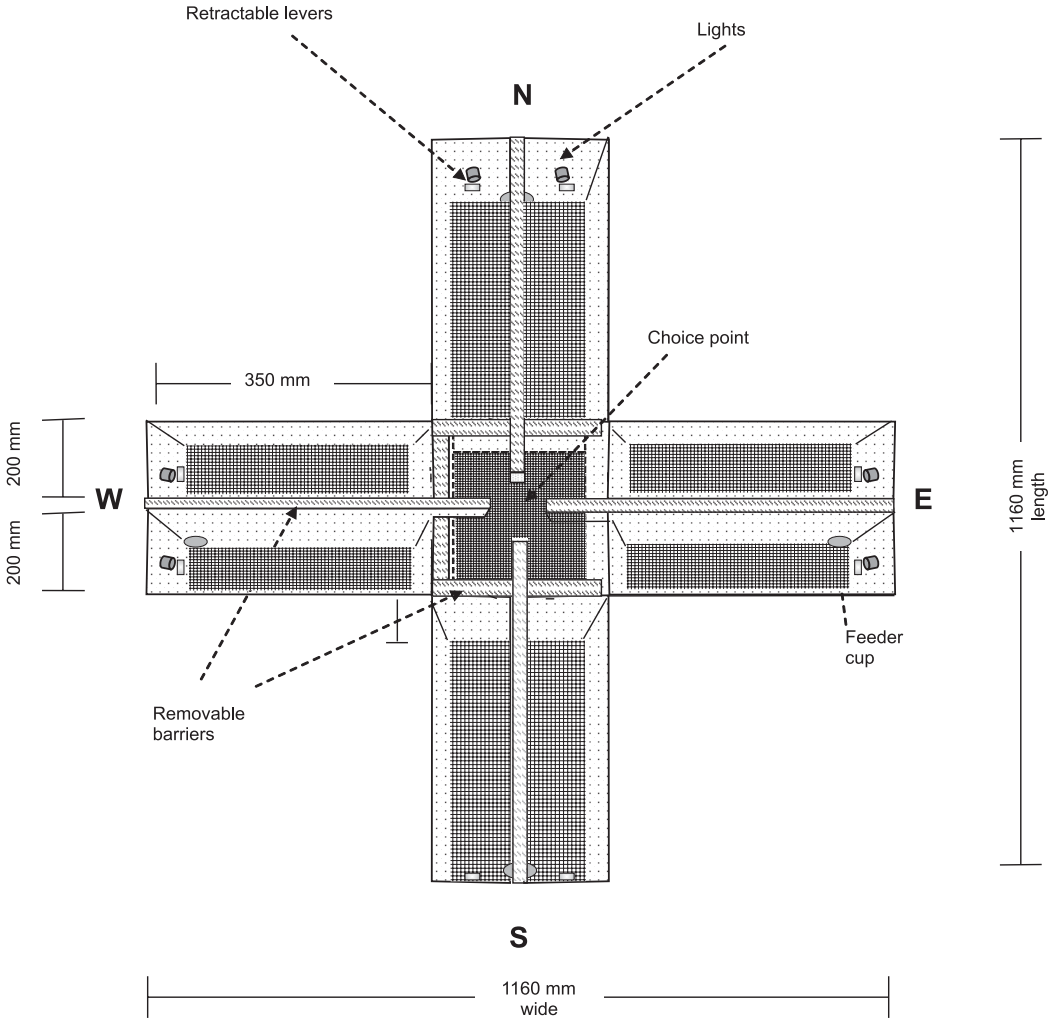

Figure 1. A drawing of the apparatus showing barriers that separated levers and chambers (see main text for details).

components. Table 1 shows the values in seconds for the random interval components that defined four sets of concurrent schedules of reinforcement (note that within each set, the sum of all numbers is 900 seconds). Each value represents the mean of 100 intervals generated by the RANDOM function of Turbo Pascal software. For each set of random interval, components thirty-five sessions were scheduled according to three conditions. In the ten sessions of the first condition (B0), there were no barriers obstructing the entrance to chambers and separating the levers; the rats entered the chambers and switched from one lever to the other without restrictions. The next condition (B1) used barriers of 300 mm to obstruct the access to the chambers and separate the levers one from another; for ten consecutive sessions the rats climbed the barriers in order to enter the chambers and switch from one lever to the other. The next condition (B2) was identical to the previous one, except that the height of the barriers was increased from 300 to 700 mm. In the last condition, a

Table 1

The values in seconds of the random interval components defining four sets of concurrent schedules of reinforcement (the subscripts R and L next to the values identify the rich and lean levers, respectively).

	SET			
Lever	1	2	3	4
1	25_R	95_R	160_L	40_R
2	50_R	80_R	215_L	35_R
3	200_L	145_L	70_R	235_L
4	175_L	130_L	105_R	140_L
5	100_R	45_R	110_L	185_L
6	75_R	30_R	165_L	90_R
7	125_L	195_L	20_R	130_L
8	150_L	180_L	55_R	45_R

redetermination of the no-barrier condition (B0) was carried out for five sessions.[1]

In all sessions each chamber provided a maximum of 15 pellets by pressing the left, the right, or both levers. The delivery of the 15th pellet caused the retraction of the levers located in the chamber where it was presented, turning off the lights above the levers. The contingencies in the other chambers remained in effect until the rats obtained the 15 pellets scheduled in each chamber, or until 90 minutes elapsed from the beginning of the session, whichever happens first.

Data analysis

With the data of the last five days of each condition, the following dependent variables were separately computed for each lever: total number of presses, presses per visit, giving-up responses, number of travels, dwell time, visit duration, and giving-up time. Presses per visit were the number of presses emitted in one lever before switching to a different lever. Dwell time was the cumulated responding time in each lever. Visit duration was the time elapsed from the first response in one lever to the last response in the same lever. Giving-up time was recorded from the last reinforcer obtained in one lever to the last response in the same lever. Giving-up responses were counted from the last reinforcer obtained in one lever to the last response in the same lever. A value of zero was assigned to giving-up times and giving-up responses when rats departure from the levers immediately after obtaining a pellet.

RESULTS

The data of visit duration and presses per visit were collapsed across the four sets of schedules of reinforcement to obtain the mean data for each lever. In Figure 2 these data were plotted as a function of barrier size. From top to bottom, each pair of panels represents data for the individuals, the eight levers are represented by different symbols connected with lines, and the unconnected symbols indicate redeterminations of the no-barrier condition.

In general, visit duration and presses per visit increased with increasing barrier size. Figure 2 shows a positive relationship between barrier size and visit duration or presses per visit. (But see the mean data of visit duration for R5 on lever 1 in the 300-mm barrier size condition.) The longest visits and the larger number of presses per visit occurred with barriers of 700-mm height separating levers and chambers. In this condition the rats did not visit levers 1, 7, and 8 (note that some filled symbols for visit duration and presses per visit are missing). This result may be due to the fact

that in three out of the four sets of RI schedules, levers 2 and 6 were associated to the richest schedules. (But see lever 1 in sets 1, 2, and 4 [Table 1]; and levers 3, 4, and 7 in set 3) In all cases, however, redeterminations (unconnected symbols) fell on or close to the original determinations.

In Figure 3 the mean giving-up times (left panels) and giving-up responses (right panels) were plotted as a function of the barrier size condition. In most cases, Figure 3 shows a positive relationship between barrier size and giving-up times or responses. In the 300-mm barrier height condition, one rat (R5) made the shortest giving-up times, and the smaller number of giving-up responses. Consistently with data of Figure 2, the longest giving-up times and the larger giving-up responses were obtained in the 700-mm barrier size condition. Redeterminations (unconnected symbols) fell close to or below the original determinations.

In Figure 4 the number of times that rats visited the levers (entries) was plotted as a function of the travel requirement (the height of the barriers); it shows a negative relationship between travel requirement and the number of entries to the levers. When barriers of 300 mm were used to separate levers and chambers, the number of entries decreased in the levers from 20 to 10 entries. Note that all symbols overlap in about 10 entries.

When the height of the barriers increased from 300 to 700 mm, the rats did not visit all

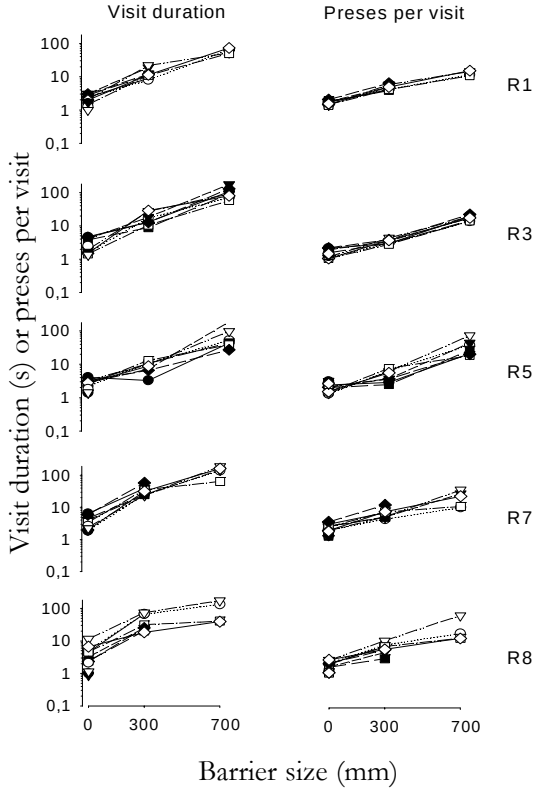

Figure 2. Visit duration and presses per visit as a function of barrier size for each rat (note the log scale on the Y-axes). The filled symbols circle, triangle, square, and rhombus represent levers 1, 3, 5, and 7, respectively; the open symbols circle, triangle, square, and rhombus represent levers 2, 4, 6, and 8, respectively.

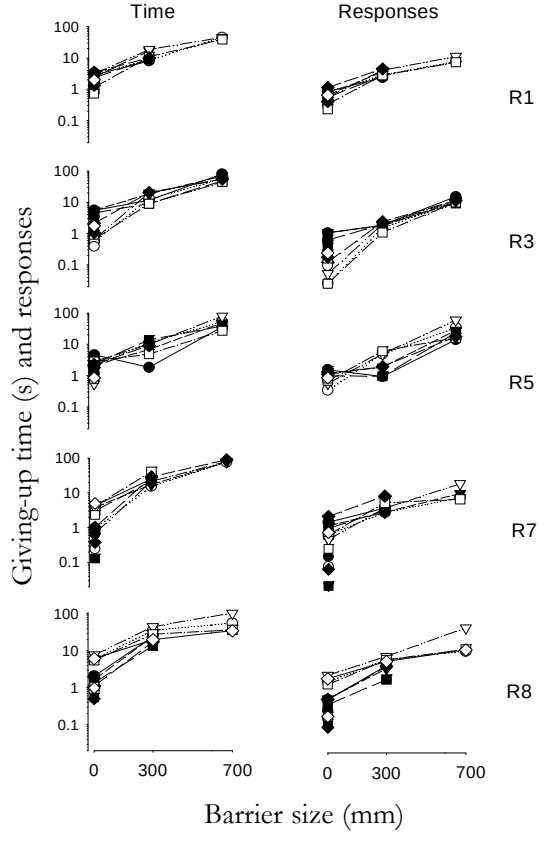

Figure 3. Giving-up times and giving-up responses as a function of the barrier size for each rat. Other details as in the Figure 2

levers. Again, this result may be due to the fact that in three out of the four sets of RI schedules, levers 2, 4, 6, and 8 were associated to the richest schedules. (But see lever 1 in sets 1, 2, and 4 [Table 1]; and levers 3, 4, and 7 in sets 3 and 2.). In conditions of 300 and 700-mm barrier height, Figure 4 shows about 10 entries to the levers for two rats (R1 and R8) that only visited four out of the eight levers. Redeterminations points (unconnected symbols) fell close to the original determinations.

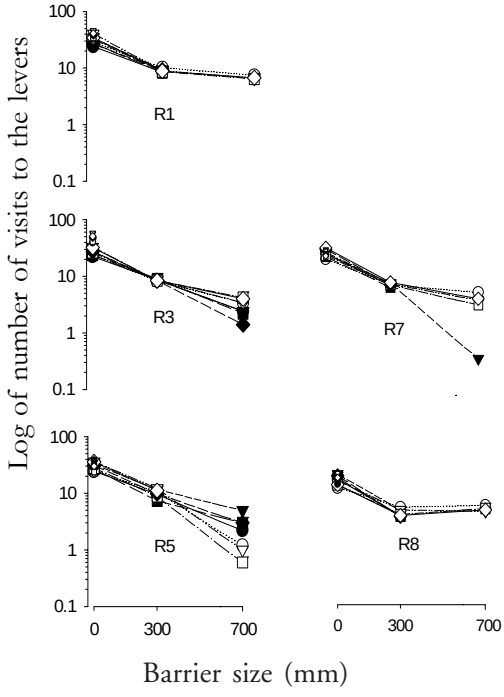

Figure 4. Number of visits to the levers as a function of the travel requirement for each rat; note the log scale on the Y axis. Other details as in the Figure 2.

The distribution of responses, dwell times, and obtained reinforcers were fitted with the following equation, analogous to Baum's (1974) generalized matching law:

$$\frac{B_i}{\sqrt[n]{B_1 \times B_2 \times \ldots \times B_n}} = b \left(\frac{r_i}{\sqrt[n]{r_1 \times r_2 \times \ldots \times r_n}} \right)^s \quad (2)$$

where *B* stands indifferently for responses or dwell times, *r* stands for obtained reinforcers, and subscripts 1 to *n* (including *i*) indicate each alternative in the choice situation. As in the generalized matching law, *b* and *s* represent bias and sensitivity, respectively.

For fitting purposes, Equation 2 was re-expressed as follows:

$$\log B_i - 1/n (\log B_1 + \log B_2 + ..\log B_n) = s [\log r_i - 1/n (\log r_1 + \log r_2 + ..\log r_n)] + \log b \quad (3)$$

For each rat and in each barrier condition, Equation 3 was fitted to the data by entering the numbers of obtained reinforcers (r_1, r_2, …, r_n) and obtained response numbers or time allocations (B_1, B_2, …, B_n) and calculating the best-fitting values of *s* and *b* by the least squares method. Equation 3 was fitted separately for each lever *i* (corresponding to a given value of B_i and a given value of r_i), and the resulting, best-fitting values of *s* and *b* were averaged across the eight levers to give a pooled estimate of the sensitivity and bias parameters (excluding the few cases where the values of R^2 were smaller than 0.25: see Appendix I).

The values of the parameter *s* obtained with Equation 3 were plotted in Figure 5 as a function of the travel requirement. The left panels show average values of sensitivity computed for distribution of responses and the right panels those corresponding to dwell time. The unconnected symbols represent redetermination to the no barrier condition.

For the distribution of responses, Figure 5 shows that sensitivity generally increased with increasing travel requirement. However, when the height of the barriers was lifted from

300 to 700 mm, for two subjects (R3 and R7) the average value of the parameter *s* remained around 1.0. The redetermination to the no-barrier condition often generated a higher average value of the parameter *s* than that obtained in the original determination, an effect that may arise from the rat's cumulative experience in the experimental situation (Todorov, Mendes de Oliveira Castro, Hanna, Bittencourt de SA, & Barreto, 1983). Importantly, however, the values obtained in the no-barrier redetermination were always *lower* than those of the 700-mm-barrier condition, which shows that the increase of response sensitivity as barrier size increased from 0 to 700 mm cannot be explained entirely in terms of cumulative experience, but must be attributed (at least in part) to barrier size.

With the exception of one subject (R1) that exhibits a positive relationship between time sensitivity and travel requirement, for distributions of dwell time Figure 5 shows that sensitivity to reinforcement changed asystematically with increasing barrier size. For one rat (R5) the average value of the parameter *s* did not change much across barrier size conditions. But for rats R3 and R8 a bitonic function between barrier size and sensitivity to reinforcement was obtained. Note that sensitivity increased from 0.5 to 1.0 when the barriers of 300 mm were introduced into the choice situation; but when barrier height increased from 300 to 700 mm, sensitivity decreased from 1.0 to about 0.5. Interestingly, a negative relationship between increasing barrier size and sensitivity to reinforcement was obtained with rat R7. In most cases, however, redetermination to the no-barrier condition generated higher values of the parameter *s* than those obtained for the original determinations. (But see rat R8, the value of the parameter *s* was smaller for the redetermination than that obtained for the original determination to the no barriers condition.)

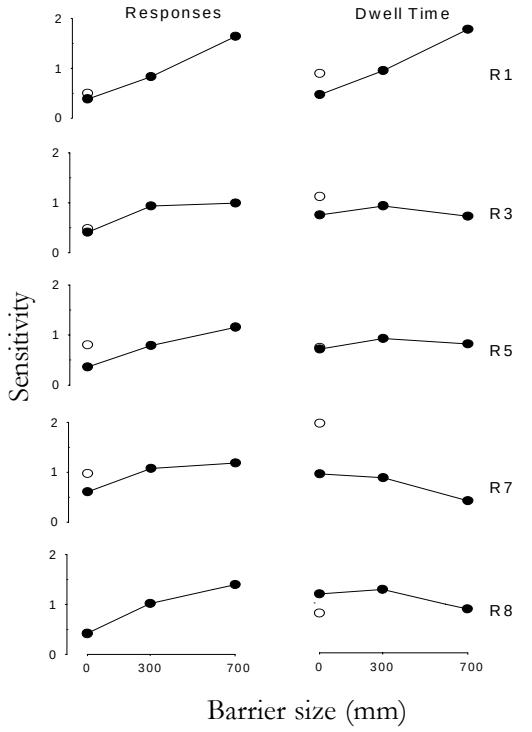

Figure 5. Value of the parameter *s*, sensitivity to reinforcement, as a function of the travel requirement for each rat. The filled circles represent determinations, and the open circles represent the redetermination to the no Barrier condition.

DISCUSSION

Consistent with results obtained in choice situations where the travel distance between two alternatives was manipulated (e.g., Aparicio, 1999, 2001), the present study showed that sensitivity to reinforcement increased with increasing travel in a situation where eight response alternatives were concurrently available. As in previous studies (Aparicio, 2001), sensitivity values for response allocation, as estimated by the parameter *s* of the generalized matching law (Baum, 1974), were higher than those obtained for time

allocation. Similar results were documented in studies where travel was simulated by requiring pigeons to peck a key (Davison, 1991), or rats to navigate from one arm to another in an eight-radial arm maze (Elsmore & McBride, 1994).

Although the procedure of the present study did not require a COD or a COR contingency, the results confirmed the findings of Aparicio and Baum (1997); climbing barriers to travel from one lever to the others seemed functionally equivalent to a COR contingency. For responses, the values of sensitivity to reinforcement were similar to those obtained with pigeons when completing a FR was required to change from one alternative to another (Dunn, 1982; Pliskoff, Cicerone & Nelson, 1978; Pliskoff & Fetterman, 1981).

The present study started with conditions where neither a COR contingency, nor climbing barriers was required for rats to traverse from one place to another. In the no-barrier condition, the results showed a distribution of responses that was less extreme than that predicted by the matching relation; the value of the parameter *s* was less than 1.0, indicating undermatching. In contrast, in the condition where barriers of 300 mm were used to separate chambers and levers, the distribution of responses matched the distribution of obtained reinforcements (*s* was close or equal to 1). Finally, in conditions where the height of the barriers was increased from 300 to 700 mm, for some rats the value of the parameter *s* was above 1.0, indicating a tendency to overmatching. Together, the results of previous studies (Aparicio & Cabrera, 2001), and the present findings suggest that in choice situations with multiple alternatives, sensitivity to reinforcement is affected by the way in which travel requirement is introduced into the choice situation; when travel is gradually introduced and when complex locomotion (i.e., climbing over barriers) is required to switch among different alternatives, overmatching is the general result (Aparicio, 2001; Baum, 1982).

In the 700-mm barrier condition, the number of visits to the levers decreased and some of the levers were not visited. However, dwell times, giving-up times, and giving-up responses increased indicating that the cost of travel (i.e., climbing over barriers) affects the way in which organisms allocate time and behavior in choice situations of multiple alternatives. These findings are consistent with predictions derived from models of optimal foraging (e.g., Anderson, 1978; Cowie, 1977; Krebs, 1978; Mellgren, Misassi & Brown, 1984; Zimmerman, 1981).

To conclude, in the present situation sensitivity to reinforcement was determined by the number of available patches (eight alternatives) and the nature of the travel requirement (i.e., complex locomotion, consisting in climbing barriers) or the way in which it was introduced into the choice situation (gradually). Further research testing the idea that overmatching is the rule to optimize resources in natural environments (Aparicio & Cabrera, 2001; Baum, 1982) should be conducted in more naturalistic situations, similar to the one used in the present experiment.

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Appendix A: Linear regression values for responses and dwell time in each lever

			Slope		Intercept		r^2	
Barrier	Rat	Lever	Responses	Time	Responses	Time	Responses	Time
0	R1	1	0.30	0.70	-0.04	0.06	0.49	0.25
		2	0.62	0.60	-0.06	-0.01	0.75	0.62
		3	0.15	0.15	0.05	-0.01	0.15	0.07
		4	0.35	0.61	0.11	0.13	0.67	0.77
		5	0.52	0.53	-0.02	-0.02	0.94	0.88
		6	-0.08	0.18	-0.01	-0.11	0.14	0.89
		7	0.22	0.42	-0.04	-0.10	0.28	0.76
		8	0.32	0.32	0.02	0.07	0.71	0.26
1		1	1.05	1.24	0.06	-0.02	0.40	0.52
		2	0.65	1.46	-0.04	-0.12	0.32	0.74
		3	0.88	0.23	-0.02	0.09	0.88	0.03
		4	1.18	0.39	0.15	0.25	0.98	0.09
		5	0.57	0.87	-0.17	-0.11	0.75	0.59
		6	0.76	1.19	-0.03	-0.01	0.82	0.89
		7	0.81	0.35	0.06	-0.06	0.72	0.87
		8	0.80	0.67	-0.01	-0.02	0.50	0.40
2		1	..	..	..	..	..	..
		2	0.12	0.86	-0.01	0.00	0.01	0.43
		3	..	..	..	..	..	..
		4	1.72	-0.03	0.08	-0.01	0.11	0.00
		5	..	..	..	..	..	..
		6	1.34	1.81	-0.03	0.01	0.97	0.99
		7	..	..	..	..	..	..
		8	1.95	2.70	-0.03	-0.01	0.61	0.85
0	R3	1	0.52	1.24	0.02	0.15	0.74	0.96
		2	0.09	0.38	-0.10	-0.24	0.05	0.39
		3	-0.07	0.09	0.11	0.21	0.08	0.03
		4	0.34	0.49	0.06	0.06	0.46	0.16
		5	0.33	0.53	-0.02	0.08	0.61	0.81
		6	-0.04	0.57	-0.11	-0.27	0.01	0.50
		7	-0.08	0.30	0.05	0.06	0.01	0.04
		8	0.44	0.90	-0.02	-0.05	0.77	0.81
1		1	1.24	1.09	0.06	0.03	0.63	0.67
		2	1.30	1.35	-0.11	-0.12	0.86	0.67
		3	0.29	0.34	0.08	0.09	0.53	0.79
		4	1.49	1.17	0.14	0.19	0.95	0.91
		5	0.96	0.77	-0.09	-0.14	0.73	0.50
		6	0.60	0.57	-0.12	-0.07	0.38	0.29
		7	1.18	1.05	0.05	-0.04	0.84	0.73
		8	0.44	0.47	-0.04	0.05	0.29	0.17

Appendix (continued)

			Slope		Intercept		r^2	
Barrier	Rat	Lever	Responses	Time	Responses	Time	Responses	Time
2		1	0.65	0.81	-0.08	-0.05	0.69	0.62
		2	0.24	0.63	-0.11	0.03	0.25	0.51
		3	0.63	0.02	0.07	-0.02	0.51	0.01
		4	1.50	0.27	-0.06	0.12	0.92	0.22
		5	1.26	1.13	-0.01	-0.08	0.81	0.88
		6	0.85	0.63	0.04	-0.01	0.96	0.86
		7	1.17	0.56	0.08	0.01	0.99	0.51
		8	0.90	0.44	0.03	0.07	0.82	0.79
0	R5	1	0.51	0.84	0.12	0.18	0.62	0.86
		2	-0.27	-0.40	-0.17	-0.34	0.41	0.64
		3	0.21	0.52	0.22	0.28	0.09	0.17
		4	0.85	1.03	-0.01	-0.03	0.99	0.54
		5	0.25	0.41	0.01	0.04	0.43	0.55
		6	-0.09	0.28	-0.14	-0.25	0.23	0.14
		7	0.11	0.66	0.08	0.14	0.83	0.50
		8	0.74	1.58	-0.12	-0.03	0.43	0.44
1		1	0.33	0.44	-0.09	-0.15	0.17	0.07
		2	0.66	0.67	-0.03	-0.06	0.18	0.20
		3	0.39	-0.01	0.19	0.21	0.14	0.00
		4	0.76	0.70	0.09	0.13	0.74	0.95
		5	1.06	1.49	-0.11	0.07	0.44	0.79
		6	0.52	0.68	-0.09	-0.13	0.12	0.15
		7	0.55	0.86	0.03	-0.06	0.43	0.83
		8	0.36	0.55	0.02	0.00	0.16	0.63
2		1	1.29	0.66	-0.12	-0.11	0.97	0.81
		2	1.17	0.95	-0.02	-0.05	0.73	0.95
		3	1.23	1.19	0.03	0.13	0.98	0.85
		4	0.41	0.43	0.19	0.13	0.66	0.77
		5	1.51	0.76	-0.04	-0.10	0.95	0.68
		6	1.71	1.14	-0.06	0.06	0.96	0.71
		7	0.78	0.40	0.02	-0.11	0.94	0.38
		8	..	..	..	..	..	..
0	R7	1	0.67	1.80	0.09	0.20	0.56	0.60
		2	-0.13	0.03	-0.22	-0.42	0.17	0.00
		3	0.15	0.34	0.06	0.14	0.15	0.20
		4	0.32	0.55	0.01	-0.02	0.27	0.46
		5	0.41	-0.04	-0.01	0.10	0.32	0.00
		6	0.05	0.09	-0.13	-0.20	0.00	0.00
		7	0.26	0.10	0.16	0.13	0.23	0.39
		8	1.04	1.29	0.03	0.03	0.84	0.79

Appendix (continued)

			Slope		Intercept		r^2	
Barrier	Rat	Lever	Responses	Time	Responses	Time	Responses	Time
1		1	1.07	0.84	0.04	0.09	0.83	0.96
		2	1.04	0.93	-0.11	-0.12	0.95	0.98
		3	1.03	0.72	0.00	0.05	0.84	0.44
		4	1.60	0.75	0.06	-0.01	0.97	0.87
		5	1.05	1.03	-0.10	-0.05	0.99	0.90
		6	0.89	0.79	-0.02	-0.05	0.84	0.87
		7	1.08	0.87	0.11	0.11	0.92	0.64
		8	0.88	0.95	0.01	-0.03	0.88	0.98
2		1	..	..	..	..	..	..
		2	1.17	-1.38	-0.07	0.37	0.27	0.51
		3	..	..	..	..	..	..
		4	1.57	1.28	0.13	-0.03	1.00	0.76
		5	..	..	..	..	..	..
		6	0.80	0.60	-0.04	-0.16	0.75	0.34
		7	..	..	..	..	..	..
		8	1.22	1.09	0.10	-0.01	0.94	0.70
0	R8	1	0.62	2.08	0.07	0.07	0.51	0.82
		2	0.20	0.87	-0.14	-0.17	0.16	0.36
		3	0.13	-0.47	0.13	0.27	0.07	0.22
		4	0.47	0.96	0.04	0.13	0.58	0.81
		5	0.44	1.33	0.01	-0.12	0.66	0.96
		6	0.29	0.87	-0.15	-0.11	0.55	0.91
		7	0.25	0.99	0.08	-0.14	0.40	0.95
		8	0.49	1.14	-0.05	0.03	0.30	0.73
1		1	1.98	1.38	0.00	0.09	0.95	0.66
		2	0.93	1.41	0.04	-0.06	0.72	0.29
		3	0.31	-0.05	-0.03	0.05	0.34	0.00
		4	1.55	1.04	0.09	0.14	0.78	0.33
		5	0.80	1.81	-0.21	-0.11	0.49	0.86
		6	0.78	1.14	0.00	-0.10	0.79	0.94
		7	1.08	0.85	0.06	-0.02	0.69	0.26
		8	0.72	1.25	0.04	-0.05	0.83	0.66
2		1	..	..	..	..	..	..
		2	1.64	-0.03	-0.11	0.24	0.88	0.00
		3	..	..	..	..	..	..
		4	1.16	-0.41	0.22	0.21	0.48	0.17
		5	..	..	..	..	..	..
		6	1.40	0.74	-0.10	-0.20	0.91	0.57
		7	..	..	..	..	..	..
		8	1.39	1.01	-0.01	-0.07	0.96	0.83