REVISTA MEXICANA DE ANÁLISIS DE LA CONDUCTA 27, 97-118 NÚMERO 1 (JUNIO)
MEXICAN JOURNAL OF BEHAVIOR ANALYSIS NUMBER 1 (JUNE)

CHOICE WITH MULTIPLE ALTERNATIVES: THE BARRIER CHOICE PARADIGM[1]

ELECCIÓN CON MÚLTIPLES ALTERNATIVAS: EL PARADIGMA DE ELECCIÓN CON BARRERA[2]

CARLOS F. APARICIO AND FELIPE CABRERA
UNIVERSIDAD DE GUADALAJARA-C.E.I.C

ABSTRACT

Three experiments assessed the generality of the matching law in situations that differed in the number of available alternatives. In different conditions reinforcement rate varied across levers according to concurrent schedules with random-interval components. Barriers (70 cm high) separated two, four, or eight levers. Rats traveled from one lever to the others by climbing over the barriers. With 2 and 4 alternatives, Experiments 1 and 2 found overmatching (preferences exceeding matching) for responses and time allocation. Experiment 3, with 8 alternatives, found overmatching in one rat for response and time allocation, but another rat showed strong overmatching only for time allocation. These results extend the generality of the matching law to choice situations with multiple alternatives. Overall, our data support the conclusion that costly locomotion leads to overmatching.

Key words: Choice, overmatching, travel, barrier, and rats.

1. This research was supported by The National Council of Science and Technology (CONACYT), Grant 28750H. Portions of this paper were presented at the 26th annual convention of the Association for Behavior Analysis, Washington, DC, 2000. Correspondence concerning this article and reprint requests should be sent to Carlos Fernando Aparicio Naranjo (aparicio@udgserv.cencar.udg.mx) or Felipe Cabrera (fcabrera@udgserv.cencar.udg.mx), Centro de Estudios e Investigaciones en Comportamiento. Av. Tepeyac 701-A Suite 189, Col. Chapalita, Zapopan, Jalisco, México CP 45040. Phone and Fax: 52-333-121-1158.

2. El presente estudio fue apoyado por el subsidio del Consejo Nacional de Ciencia y Tecnología, proyecto número 28570H. Recibido por RMAC el 10 de marzo 2001 y aceptado el 13 de julio 2001.

RESUMEN

La generalidad de la ley de igualación se evaluó en tres experimentos que difirieron en el número de alternativas que tenían disponibles. En diferentes condiciones la tasa de reforzamiento varió en las alternativas de acuerdo a programas concurrentes con componentes de Intervalo Aleatorio. Barreras de 70 cm de altura se usaron para separar dos, cuatro u ocho palancas. Para viajar de una palanca a las otras las ratas tenían que escalar las barreras. Con dos y cuatro alternativas, los experimentos 1 y 2 encontraron sobreigualación (preferencias que excedieron la igualación) para las distribuciones de respuestas y de tiempo transcurrido en las palancas. El Experimento 3, con ocho alternativas, en una rata mostró sobreigualación para distribuciones de respuestas y de tiempo, sin embargo en otra rata la sobreigualación sólo ocurrió para las distribuciones de tiempo. Estos resultados extienden la generalidad de la ley de igualación a situaciones de elección con múltiples alternativas. En general, nuestros datos apoyan la conclusión de que la locomoción costosa conduce a la sobreigualación.

Palabras clave: elección, sobreigualación, viaje, barrera, ratas.

In two-alternative choice situations Herrnstein's (1961) matching law describes the general pattern of results as

$$B_1 / B_2 = r_1 / r_2 \qquad (1)$$

where B_1 and B_2 represent behavior allocated to Alternatives 1 and 2, respectively, and r_1 and r_2 are the reinforcement rates obtained from Alternatives 1 and 2 as a result of B_1 and B_2.

Deviations from Equation 1 are accounted by the generalized matching law (Baum, 1974):

$$\log (B_1 / B_2) = s \log (r_1 / r_2) + \log b \qquad (2)$$

where *s* represents the sensitivity of the behavior ratio, (B_1 / B_2), to variation in the reinforcement ratio, (r_1 / r_2), and *b* represents a bias in favor of one or the other alternative. Accordingly, matching is obtained when *s* and b both equal 1.0. A deviation from matching, called *undermatching,* is represented by a value of *s* less than 1.0, meaning that the changes in the behavior ratio, (B_1/ B_2), are less extreme than in the reinforcement ratio, (r_1/ r_2). When behavior is disproportionately allocated in favor of the richer schedule, *s* exceeds 1.0, a deviation from matching that Baum (1979, 1982) called overmatching. Some reviews on choice (e.g., Wearden & Burgess, 1979; Mullins, Augunwamba, & Donohoe, 1982) conclude that undermatching (slope less than 1.0) is a predominant result in situations where the organism changes freely from one alternative to the other (for a summary, see Davison & McCarthy, 1988). However, it has been shown that with extended training the slope can change from matching to undermatching

(Keller & Gollub, 1977), or that the slope can increase or decrease with scheduling of reinforcement (Davison, 1982; Taylor & Davison, 1983).

Overmatching (*s* 1.0), in contrast, is obtained when a changeover delay (COD; a short delay following a switch ,during which no response can be reinforced) is imposed on the behavior of switching from one alternative to another (e.g., Todorov, 1971, 1982; Davison, 1991; Davison & Douglas, 2000). Research on changeover requirements indicates that sensitivity *s* increases with: a) longer durations of the COD (Shull & Pliskoff, 1967), b) longer fixed-ratio changeover requirements (Pliskoff & Fetterman, 1981), and c) longer costs of changeover (Baum, 1982; Dunn, 1982 for summary).

Sensitivity also increases when the operant conditioning chamber is modified to include locomotion (Krebs, Kacelnik, & Taylor, 1978; Ydenberg, 1984; Baum, 1982; Boelens, & Kop, 1983), suggesting that overmatching results when the situation imposes a cost on the behavior of moving from one place to another. The generality of this finding has been extended with rats responding in a situation where running was required to move from one lever to another when the levers were separated by a barrier (Baum & Aparicio, 1999). Although previous studies conducted in the same situation (Aparicio & Baum, 1997) confirmed that locomotion and lever pressing have similar effects on choice, recent research where climbing over a barrier was required to travel from one lever to the other (Aparicio, 1998, 1999) showed that for rats climbing a barrier is a more costly requirement than running from one site to another; climbing as a travel requirement produced strongest overmatching (Aparicio, 2001).

The use of this method, known as the Barrier Choice Paradigm, increases the ecological validity of the study of choice in the operant laboratory. Climbing over obstacles to travel from one site to another resembles a forager's locomotion in natural environments. However, when searching, foragers usually face more than two alternatives. To model this situation, the present study adapted the barrier choice paradigm to include 2, 4, or 8 alternatives. The idea was to compare choice behavior under circumstances where the number of alternatives differed from one condition to another, and complex locomotion was required to travel from one site to the others.

EXPERIMENT 1

In previous studies (Aparicio, 2001), barriers of 30.5 and 45.7 cm were used to separate two levers that concurrently provided food according to two random-interval schedules. With the 30.5 cm barrier, the generalized matching law showed sensitivities equal to or slightly above 1.0 for response and time allocation. With the 45.7 cm barrier the generalized matching law showed sensitivities above 1.2 for responses and time allocation, indicating that sensitivity to reinforcement increased with increasing barrier height. Experiment 1 extended the generality of these findings to a choice situation where a 70 cm barrier was used to separate two levers that concurrently provided food according to two random-interval schedules.

METHOD

Subjects

Four naive male Wistar rats (R2, R4, R5, and R11), between 100 and 120 days old, participated as subjects. The rats weighted between 300 and 320 g before starting food deprivation and were maintained at 85% of their free-feeding weights. Water was available in their home cages, and the animals were maintained on a 12:12 hr light / dark cycle.

Apparatus

The apparatus has been described in detail elsewhere (Aparicio, 1998, 1999). Figure 1a shows a diagram of the floor plan of the chamber, which measured 38x38 cm with two retractable response levers (MED ENV-112) operated by a force of 0.2 N, one on each side of the anterior wall. The box was divided in two equal parts by placing a 70 cm high wire mesh barrier between the levers. The rats had to climb over the barrier to switch from one lever to the other. An aperture (3 cm wide and 5 cm high), located in the bottom front part of the barrier, allowed rats to obtain food (45-mg Noyes Formula A pellets) from the hopper from either side of the chamber. Two 24-V DC stimuli lights centered 4 cm above the levers and 17 cm above the floor provided ambient illumination.

Procedure

With a 30-cm barrier placed between the levers, the rats were trained to lever press for food by using the autoshaping technique (Brown & Jenkins, 1968). When the animals consistently pressed on the levers, the barrier size was increased from 30 to 70 cm, and the experiment began. All sessions started by inserting the levers into the chamber and turning on the lights above the levers. Pressing the left and the right levers was reinforced with food according to two concurrent random-interval (RI) schedules. In different conditions, the rate of reinforcement was varied across levers according to five pairs of RI schedules: 200-200, 200-400, 200-600, 200-800, and 200-1000 s (for the left and right levers, respectively). These numbers were the mean values of 100 intervals generated by the Random function of Turbo Pascal. Note that reinforcement rate on the left lever remained constant, whereas it decreased on the right lever across conditions. All conditions were in effect for at least 20 sessions and until the log ratios (L/R) of lever presses

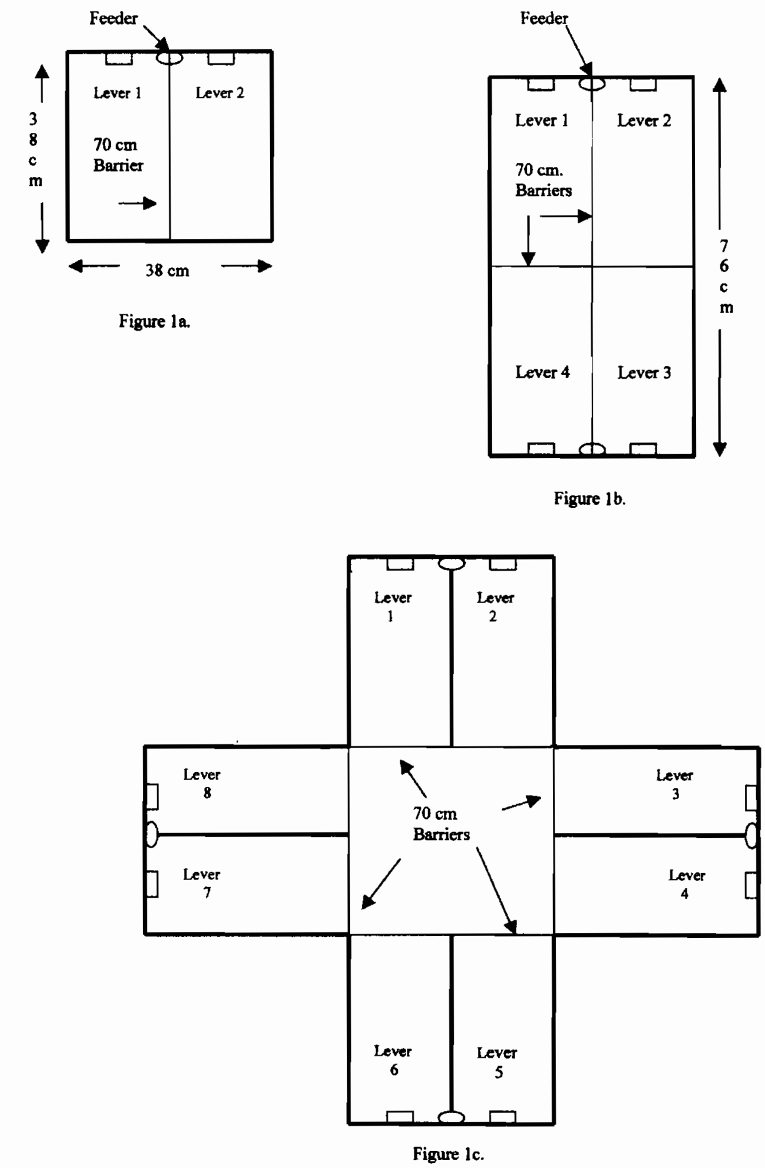

Figure 1. *Drawings of the apparatus adapted to include 2, 4, or 8 levers. Note the 70-cm-high barriers separating the levers and access to different alleys.*

and obtained reinforcements did not vary by more than 5% across five consecutive sessions. All sessions ended when 60 pellets were obtained or after 90 min, whichever came first.

Daily sessions were conducted in a lighted room. 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).

Data analysis

For each lever, the following dependent variables were computed: number of lever presses, number of obtained reinforcers, and residence time. Residence time was computed from the first response on one lever to the last response on the same lever. Data from the last 5 days of each condition were averaged and used in the analysis of the results.

Because one goal of the present study was to compare choice in situations that differed in the number of alternatives concurrently available, Experiment 1 used the following version of Equation 2 that Natapoff (personal communication, 1991) suggested for choice situations with two or more alternatives

$$\frac{B_1}{\sqrt[n]{B_1 B_2 \ldots. B_n}} = \frac{r_1}{\sqrt[n]{r_1 r_2 \ldots. r_n}} \qquad (3)$$

where B represents response numbers, r reinforcer numbers, and subscripts *1* to *n* the alternatives available in the choice situation. Note that the expressions in the denominators represent the geometric means of responses and obtained reinforcers. Equation 3 can be re-expressed to capture Baum's (1974) generalized matching law as follows:

$$\log B_1 - \frac{1}{n}\left(\log B_1 + \ldots. \log B_n\right) = s\left[\log r_1 - \frac{1}{n}\left(\log r_1 + \ldots. \log r_n\right)\right] + \log b \qquad (4)$$

In the present studies, Equation 4 was used to fit lines to all data points, whether the choice situation included 2, 4, or 8 alternative. The idea was to express the distributions of responses, and time allocation on the available alternatives with the same metric. Thus, response allocation, time allocation, and reinforcer distribution were computed and transformed into logarithms of base 10. The logarithms of response allocation and those of time allocation were entered on the left side of Equation 4, and the logarithms of reinforcer distribution were entered on the right side of Equation 4.

RESULTS

The number of responses (upper panels), residence times (lower panels), and the number of obtained reinforcers (middle panels) on the left (open circles) and the right levers (filled circles) were plotted in Figure 2 as a function of the different conditions. The filled rhombus (right lever) and the open rhombus (left lever) represent re-determinations of the first condition.

In the first condition (CONC RI200-RI200 s) the rats preferred the right lever (filled circles) over the left lever (open circles). The multiple panels of Figure 2 show a greater number of lever presses, longer residence times, and a higher number of obtained reinforcers for the right lever than for the left lever. Across conditions the number of lever presses, residence times, and number of obtained reinforcers increased on the left lever (where the rate of reinforcement remained constant). On the right lever, by contrast, the number of lever presses, residence times, and the number of obtained reinforcers decreased with the decreasing rate of reinforcement scheduled across conditions. After passing through all conditions the rats behaved indifferently with respect to the left and right levers. The re-determination points for Condition 1 (rhombi) show that the number of lever presses, residence times, and the number of obtained reinforcers were similar for the left and right levers.

The logarithms (base 10) of response allocation (filled circles) and those of time allocation (open circles), were plotted in Figure 3 as a function of the logarithms (base 10) of obtained reinforcer distribution. The lines were fitted to the data points by using the least-squares method. The resulting equations appear near the regression lines (subscripts r and t indicate fits for responses and time allocation, respectively).

The obtained slopes, ranging from .78 to 1.19, show that both response allocation and time allocation were positively related to reinforcer distribution. With two exceptions (responses for R5, and time allocation for R4), the slopes indicate that distribution of response and time allocation overmatched the reinforcer distribution. Although the choice slopes for response allocation appear to be greater (average slope = 1.09) than those of time allocation (average slope = 1.05), they were not significantly different from each other on a sign test ($p = 1.0$). All intercepts have negative values, indicating that the rats had a bias for the left lever. The regression equations generated good fits for response allocation (Mean $r^2 = .96$) and time allocation (Mean $r^2 = .97$).

EXPERIMENT 2

A second experiment was conducted to assess the generality of the matching law with rats responding in a choice situation that had four alternatives and required complex locomotion (climbing a barrier) to travel from one site to the others.

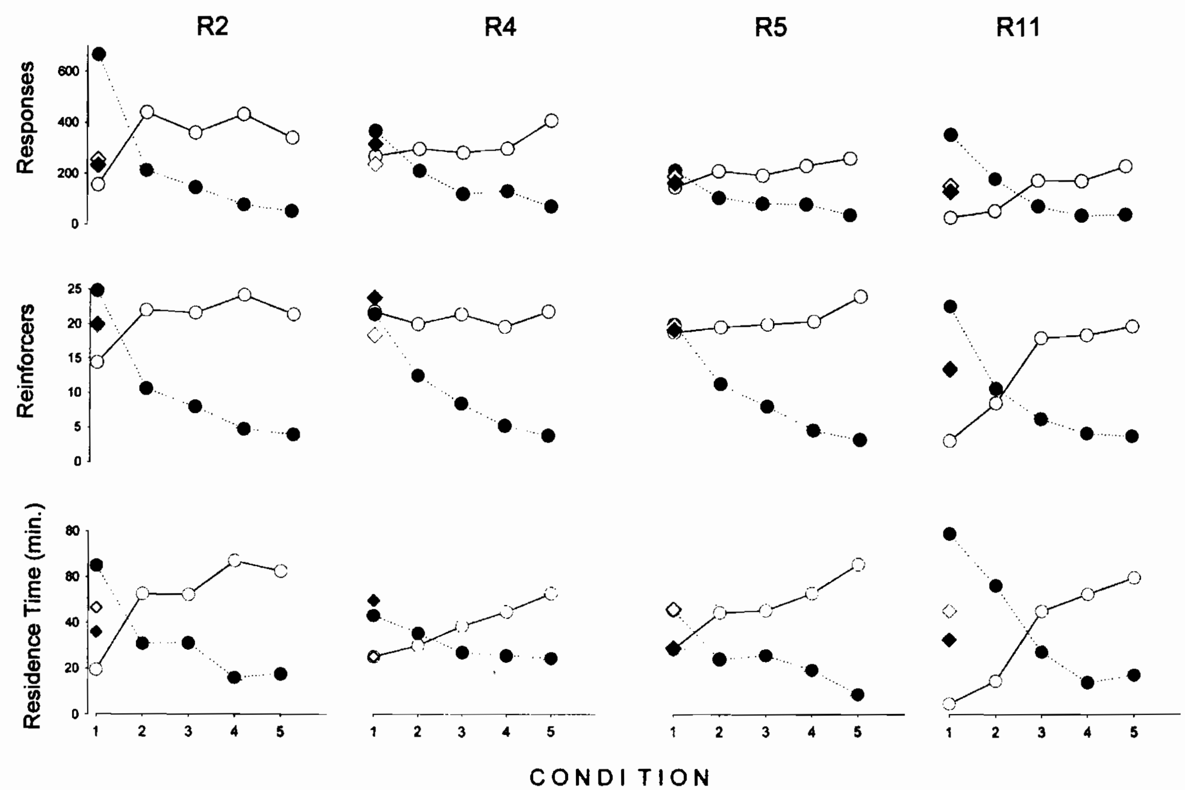

Figure 2. For each rat that participated in Experiment 1, number of lever presses, obtained reinforcers, and residence time on the left (open circles) and right (filled circles) levers. Empty (left lever) and filled (right lever) rhombi indicate a re-determination of the first condition (CONC RI200-RI200 s).

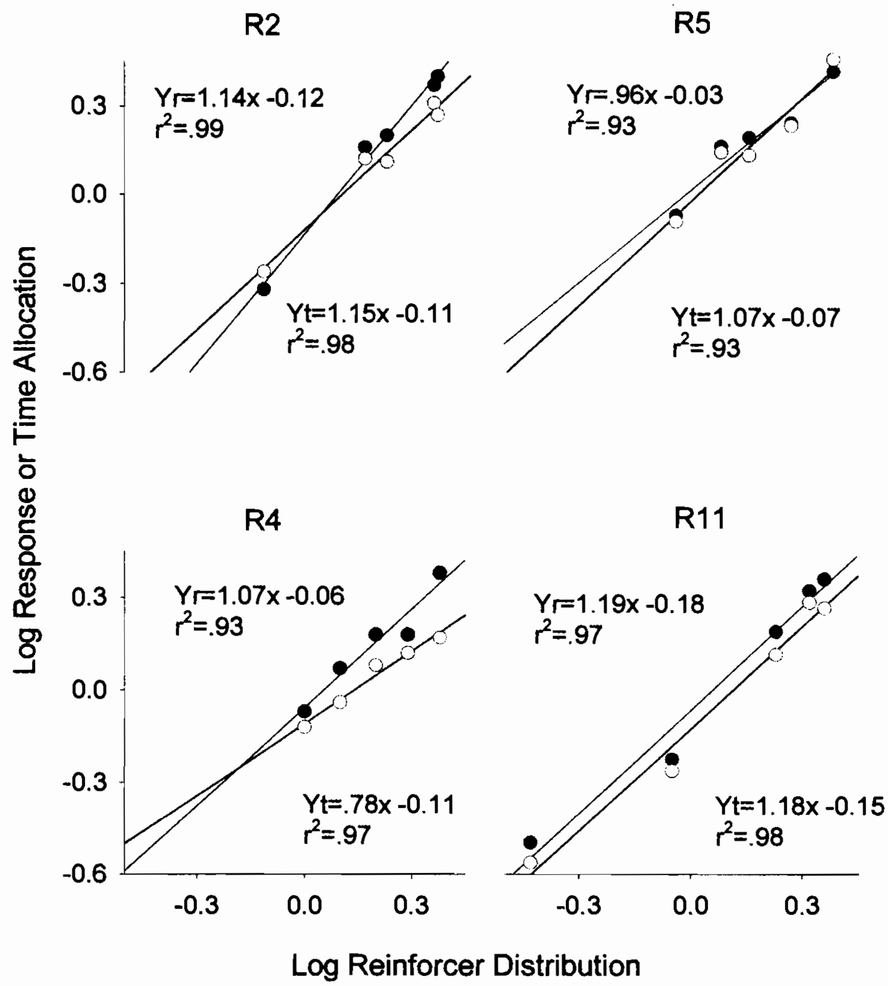

Figure 3. *The response allocation (left panels) and time allocation (right panels) as a function of the reinforcer distribution (note the use of logarithms of base 10) for each rat that participated in Experiment 1. The open circles represent data for responses and the filled circles data for time allocation. The resulting equations appear near the fitted lines. Subscripts r and t represent responses and time allocation, respectively.*

METHOD

Subjects

Four naive male Wistar rats (R3, R6, R8, and R9), between 100 and 120 days old, participated as subjects. The rats weighted between 300 and 320 g before the start of food deprivation and were maintained at 85% of their free-feeding weights. Water was available in their home cages, and the animals were maintained on a 12:12 hr light / dark cycle.

Apparatus

Experiment 2 employed the same apparatus that was used in Experiment 1. Adding one box identical to that one described in Experiment 1 created a choice situation with four alternatives (Figure 1b). The back wall of each box was removed and the boxes were coupled with latches. A 70-cm-high wire mesh barrier was placed between the boxes, giving the choice situation the shape of a rectangular box of 76 cm by 38 cm height.

Procedure

Experiment 2 used a procedure similar to that used of Experiment 1. In different conditions that lasted for at least 20 days, the rate of reinforcement was varied across levers according to five quadruplets of RI schedules: 200-200-200-200, 200-400-200-400, 200-600-200-600, 200-800-200-800, and 200-1000-200-1000 s. The rate of reinforcement remained constant on Levers 1 and 3 (corresponding to 18 per hour), but it decreased across conditions on Levers 2 and 4 (given the increasing values of random-interval components, the rate of reinforcement was reduced from18 to about 3.6 reinforcers per hour on these levers).

Data analysis

Similar to that of Experiment 1. Response allocation, time allocation, and reinforcer distribution were calculated onto equations 3 and 4.

RESULTS

The number of responses (upper panels), residence times (lower panels), and the number of obtained reinforces (middle panels) were plotted in Figure 4 as a function of the different conditions. The open symbols represent the data obtained on Levers 1 and 3, and the filled symbols the data obtained on Levers 2 and 4 (see Figure 1b). The multiple panels show that on Levers 1 and 3, lever presses

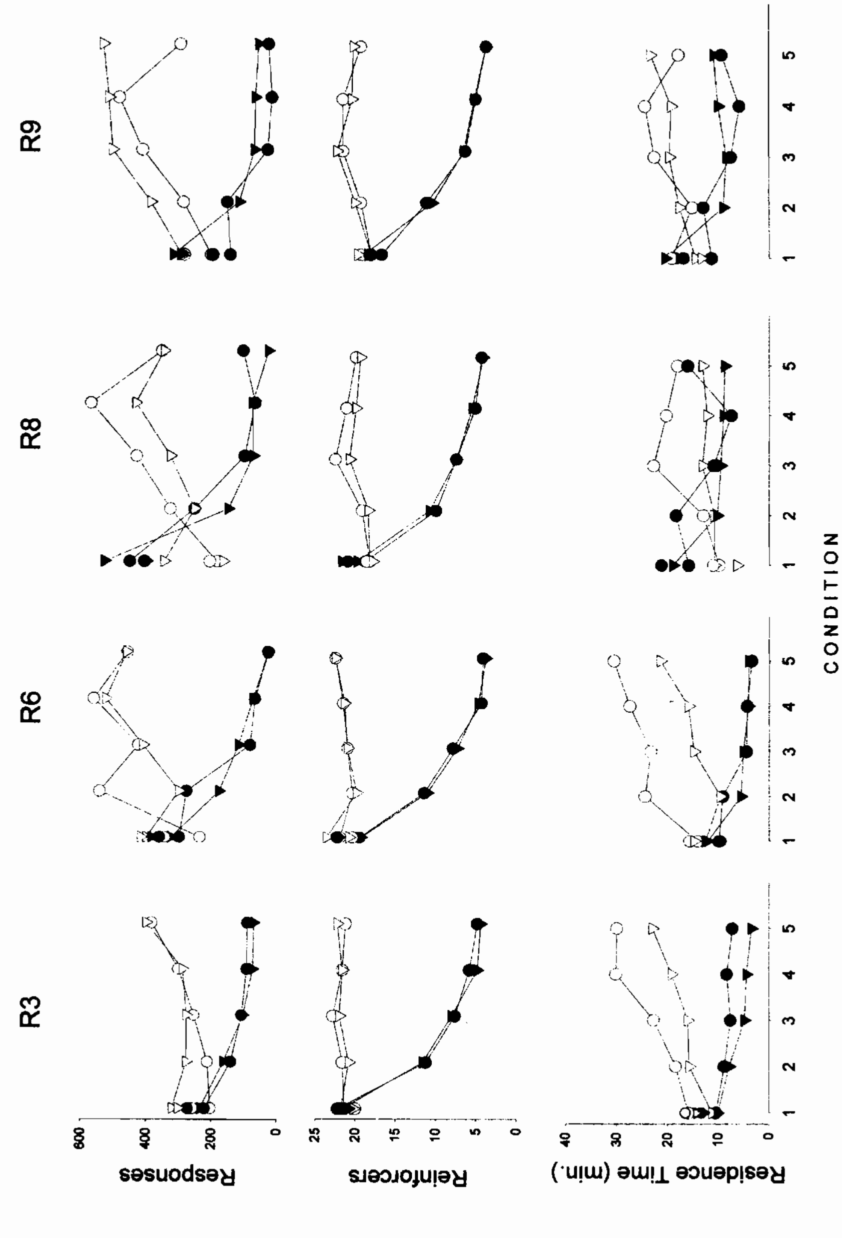

Figure 4. For each rat that participated in Experiment 2, the number of lever presses, obtained reinforcers, and residence time in the left (open circles) and right (filled circles) levers.

(upper panels) and residence times (bottom panels) increased across conditions, whereas the obtained number of reinforcers remained relatively constant (see middle panels). On Levers 3 and 4, the multiple panels of Figure 4 show that lever presses, residence time, and obtained reinforcers decreased with the decreasing rate of reinforcement scheduled across conditions.

In Figure 5 the logarithms (base 10) of response allocation (left panels), and those corresponding to time allocation (right panels), were plotted as a function of the logarithm (base 10) of reinforcer distribution. The lines were fitted to the data points by using the least-squares method (the resulting equations appear near to regression lines). The multiple panels of Figure 5 show that response allocation and time allocation were positively related to reinforcer distribution. For response allocation (left panels) the slopes ranged from .76 to 1.17 (average slope = .99), and for time allocation (right panels) the slopes ranged from .33 to 1.13 (average slope = .79). The choice slopes for responses were not significantly different from those of time allocation on a sign test ($p = 1.0$). With the exception of one aberrant fit for time allocation (R8), the linear equation generated good fits for response distributions (average $r^2 = .92$) and time allocation (average $r^2 = .85$).

EXPERIMENT 3

Experiment 2 showed that the matching law holds in choice situations where four response alternatives are concurrently available, and complex locomotion is required to travel from one site to the others. Experiment 3 extended the generality of these results to a choice situation that included eight alternatives and required the rats to climb barriers of 70 cm to travel from one place to another when searching for food.

METHOD

Subjects

The same rats that participated in Experiment 2 participated as subjects in Experiment 3.

Apparatus

Experiment 3 used the apparatus of Experiments 1 and 2. Creating a choice situation with eight alternatives required assembling four identical boxes in the shape of a 112-cm^2 cross (see Figure 1c). A plywood square frame (45 cm^2) covered with wire mesh was placed in the center of the cross and used to join the boxes (each without back wall). Barriers of 70 cm were placed on the back of each

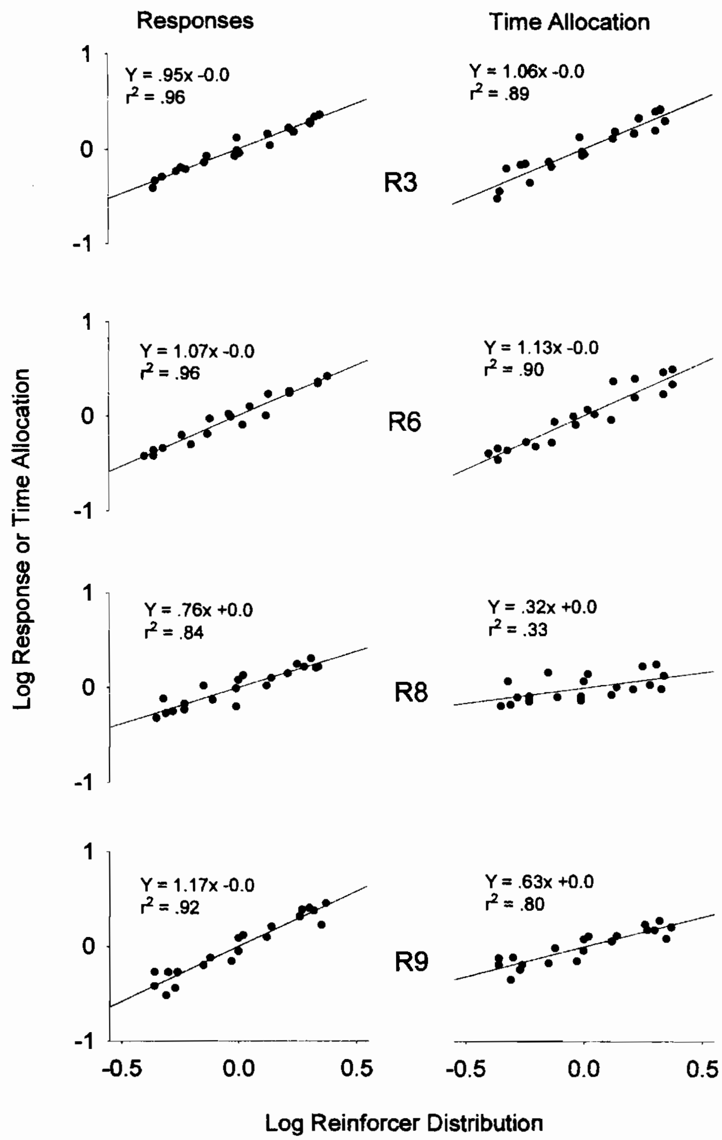

Figure 5. *The response allocation (left panels) and time allocation (right panels) as a function of the reinforcer distribution (note the use of logarithms of base 10) for each rat that participated in Experiment 2. Other details as in Figure 3.*

box, forcing the rats to climb up and down when traveling from the floor of the center of the cross to any of the four arms or boxes. Thus, the rats had to climb a 70-cm-high barrier to switch from one lever to any other.

PROCEDURE

Experiment 3 used a procedure similar to that of Experiments 1 and 2. The rate of reinforcement varied across levers according to the following five 8-schedule combinations: 200-200-200-200-200-200-200-200, 200-400-200-400-200-400-200-400, 200-600-200-600-200-600-200-600, 200-800-200-800-200-800-200-800, and 200-1000-200-1000-200-1000-200-1000 s. Whereas for the odd levers (1, 3, 5, and 7) the reinforcement rate remained constant, for the even levers (2, 4, 6, and 8) the rate of reinforcement decreased across conditions.

RESULTS

Lever presses (upper panels), residence time (lower panels), and the obtained number of reinforcers (middle panels) were plotted in Figure 6 as a function of the different conditions. The open symbols represent data for the odd levers (1, 3, 5, and 7) and the filled symbols data for the even levers (2, 4, 6, and 8; see Figure 1c). For the odd levers where the rate of reinforcement remained constant (empty: triangles, squares, rhombi, and circles), Figure 6 generally shows that lever presses (upper panels) and residence times (bottom panels) increased across conditions. A few exceptions occurred: the data of Rat 6 on lever 7 (empty rhombi) for conditions 2 and 3, and the data of all rats on levers 3 and 7 (empty triangles and rhombi) for conditions 4 and 5. With some variations, the middle panels show that for rats 3 and 6 the number of obtained reinforcers increased on the odd levers across conditions. In conditions 4 and 5 rats 8 and 9 obtained less reinforcers than in the first three conditions (empty symbols in the middle panels of Figure 6).

For the even levers (2, 4, 6, and 8) the multiple panels of Figure 4 show (filled symbols) that lever presses, residence times, and obtained reinforcers generally decreased across conditions with the decreasing rate of reinforcement. However, note the residence times of rat 8 on lever 4 (filled triangles) across conditions.

In Figure 7 the logarithms (base 10) of response allocation (left panels) and those corresponding to time allocation (right panels), were plotted as a function of the logarithms (base 10) of reinforcer distribution. The lines were fitted to the data points by using the least-squares method (resulting equations appear near the regression lines). The multiple panels of Figure 7 show that both response allocation and time allocation were positively related to reinforcer distribution. For response allocation (left panels) the choice slopes ranged from .84 to 1.10

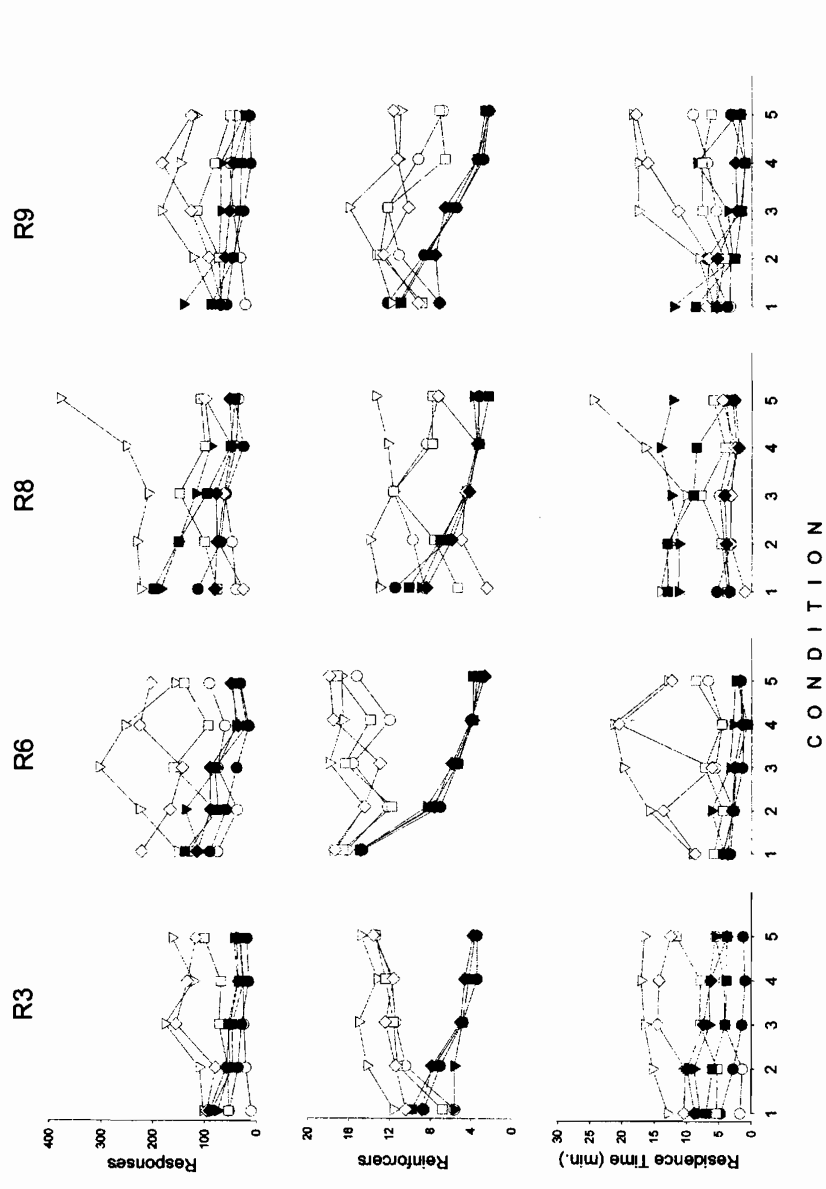

Figure 6. For each rat that participated in Experiment 3, the number of lever presses, obtained reinforcers, and residence time on the left (open circles) and right (filled circles) levers.

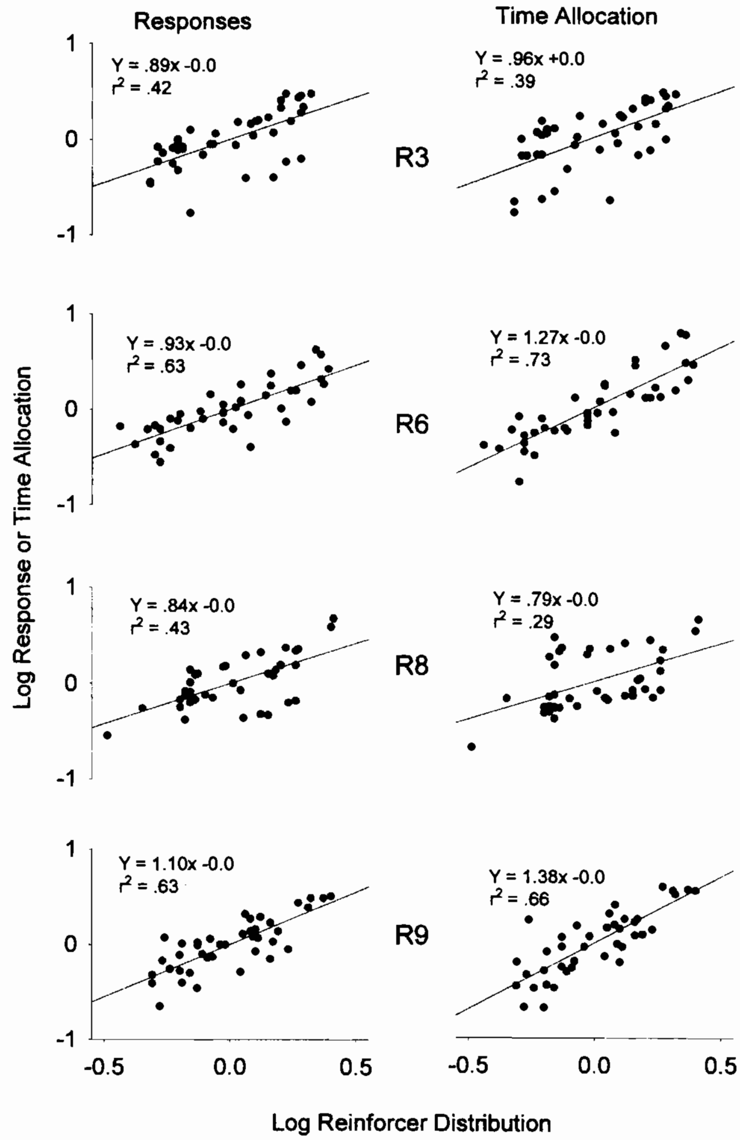

Figure 7. The response allocation (left panels) and time allocation (right panels) as a function of the reinforcer distribution (note the use of logarithms of base 10) for each rat that participated in Experiment 3. Other details as in Figure 3.

(average slope = .94); for time allocation (right panels) the choice slopes ranged from .79 to 1.38 (average slope = 1.1). The choice slopes for response allocation were not significantly different from those of time allocation on a sign test (p = .625). Generally, the linear equation generated poor fits for response allocation (Mean r^2 = .53) and time allocation (Mean r^2= .52).

GENERAL DISCUSSION

In the present study choice situations with 2, 4, or 8 alternatives showed a common result: lever presses and résidence times increased on the odd levers, where the rate of reinforcement remained constant across conditions. This result can be interpreted as a form of behavioral contrast (Reynolds, 1961), which usually is studied with multiple schedules of reinforcement (Williams 1976, 1979, 1981). However, a modified version of the matching law equation may account for behavioral contrast. For example, Herrnstein (1970) analyzed the data of Rachlin and Baum's study (1969) that manipulated the duration of reinforcement on one key while on a second key the schedule of reinforcement remained constant. On the key associated with unchanged reinforcement, Rachlin and Baum (1969) found that response rate varied inversely with the duration of reinforcement for the other key. When Herrnstein selected the appropriate parameters values for the average group, he found that the data from Rachlin and Baum's study did not deviate by more than 6 responses per minute from a perfect fit of a modified version of the matching law (Herrnstein, 1970). Thus, the matching law accounts for both behavioral contrast in multiple schedules and matching in concurrent schedules (for a review, see Williams, 1983).

The results of Experiment 1 confirmed the notion that choice situations with costly locomotion lead to overmatching (Aparicio, 2001). In the two-alternatives choice situation (Experiment 1), where the rats were required to climb a 70 cm high barrier to switch from one lever to the other, three out of four slopes for responses and time allocation were above 1.0. This result, known as overmatching (Baum, 1974), is consistent with that found in previous studies in our laboratory (Aparicio, 1998, 1999, 2001), and with results obtained in choice situations that included travel (Baum, 1982; Boelens & Kop, 1983; Aparicio & Baum, 1997; Baum & Aparicio, 1999). Experiments 2 and 3 extended this finding: in the situation with 4 alternatives four out of eight slopes showed overmatching for responses and time allocation. Although in the 8-alternative situation only one rat (R9) showed slopes above 1.0 for responses and for time allocation, another rat (R6) showed strong overmatching (slope 1.27) for time allocation. Thus, the results of experiments 2 and 3 extend the applicability of the matching law to choice situations where several alternatives are concurrently available and a complex form of locomotion (climbing barriers of 70 cm) was required to travel from one alternative to the others. Also, in choice situations with 4 and 8 alternatives, the Natappof's modified version of the generalized matching law accounts well for variations in response distribution and time allocation.

Although in theory the matching law applies to choice situations with more than two alternatives (de Villiers & Herrnstein, 1976; Herrnstein, 1974). Previous efforts aimed at increasing the number of alternatives (Pliskoff & Brown, 1976; Miller & Loveland, 1974; Davison & McCarthy, 1994; Davison, 1996) were not able to include more than three (due to the reduced space of the standard operant chamber). Moreover, in these studies animals remained in the same chamber while responding in a lever or a key. Other studies with three alternatives (Reynolds, 1963; Davison & Temple, 1974; Mazur, 2000) differed from the present study in that they used concurrent chained schedules. In those studies two out of three alternatives were available only in the initial link of the concurrent chained schedules. To our knowledge, the only study of choice with eight alternatives concurrently available was conducted by Elsmore & McBride (1994). However, to vary the rate of reinforcement across the 8 alternatives of their eight-arm radial maze configuration, Elsmore and McBride used concurrent schedules with fixed-interval (Experiment 1) and random-interval (Experiment 2) components. Although the values of the schedules differed across alternatives, Elsmore and McBride did not analyze changes in behavior sensitivity across conditions (they analyzed the same set of values for each condition separately). Besides, Elsmore and McBride's study did not require complex locomotion (such as climbing over a barrier) to move from one site to another. Finally, the study of Elsmore and McBride did not offer any way to compare choice behavior with 2, 4, and 8 alternatives; our study does permit such comparison. To further support this point, travel time and the number of travels were averaged across rats and plotted in Figure 8 as a function of the number of available alternatives in the choice situation. The two-alternative situation shows the longer travel time (latched bar) and the smaller number of travels (white bar). Figure 8 shows the opposite result for the four-alternative situation the rats emitted the shorter travel time and the larger number of travels. The eight-alternative situation shows an averaged travel time and number of travels that fall in between those corresponding to the two and the four-alternative situations. It appears that the complexity of the choice situation determines the duration of the travel time, as well as the number of times that the animals visit the available alternatives. However, perhaps this result was due to the way in which travel time was recorded. It was computed as the time elapsed from the last response in one alternative to the first response in the other alternative. So, if a rat stopped responding to one alternative and remained in the same place, this counted as travel time until the rat emitted a response in another alternative. This result was informally observed to happen with more frequency in the two-alternative situation than in the four or the eight-alternative situation, where the animals did not waste their time sitting into the same spot. The difference in the number of travels between situations with four and eight alterna-

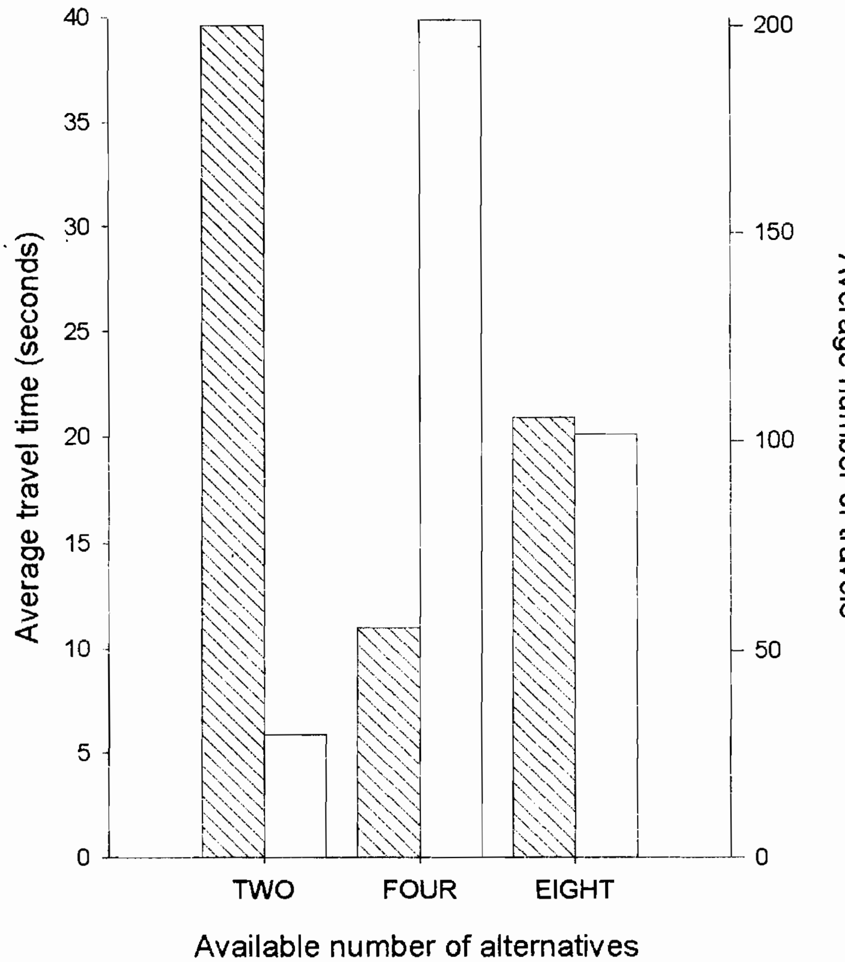

Figure 8. *Travel time (latched bars) and number of travels (white bars) to each alternative as a function of the number of available alternatives in the choice situation. Data were averaged across rats.*

tives can be easily understood if we remember that the eight-alternative situation had more barriers separating the levers than the four-alternative situation.

In sum, these experiments extended the utility of the barrier-choice paradigm to study foraging-related choices in situations with multiple alternatives. Our data generally support the conclusion that when costly locomotion is needed to travel from one site to the others, the organism's sensitivity to reinforcement is enhanced.

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