

THE MATCHING LAW IN HAMSTERS

Izumi Furuya, Shoko Inada
and Shigeru Watanabe

Keio University

ABSTRACT: Most studies of the matching law have used pigeons or rats. Hamsters usually do not consume food immediately but store it in their cheek pouches. In the present experiment, three hamsters were trained on Concurrent Variable Interval-Variable Interval (Conc VI-VI) schedules with food reinforcement in an operant chamber with two levers. The value of the VI schedule was changed from 10 s to 90 s. A linear regression of log reinforcement ratio to log response ratio described the choice behavior of the hamsters well. These results suggest the applicability of the generalized matching law to operant behavior that is not immediately followed by consummatory behavior.

INTRODUCTION

Herrnstein (1970) described a matching relationship between relative frequency of operant responding and relative frequency of reinforcement when two independent schedules of reinforcement were concurrently effective. Since then, there have been many studies demonstrating robustness of the matching law (Baum, 1979; Wearden & Burgess, 1982). The matching relationship has been obtained not only with food reinforcement but also with aversive reinforcers (Hutton, Gardner & Lewis, 1978) and brain stimulation (Gallistel, 1969). Although the matching law has been applied to cows (Matthews & Temple, 1979), monkeys (Liewellyn, Iglauer & Woods, 1976), dogs (Rashotte & Smith, 1984), free ranging wild pigeons (Baum, 1974a) and wagtails in the wild (Houston, 1986), most studies of matching have used rats or pigeons. Hamsters have a peculiar feeding pattern in that they do not consume food immediately but keep it in their cheek pouches, and consume it usually when they return to their nest. Hamsters also show food

Address correspondence to Shigeru Watanabe, Department of Psychology, Keio University, Mita 2-15-45, Minato-Ku, Tokyo, Japan.

hoarding behavior (Phillips, 1989; Wong, 1984). Therefore, a food pellet given to a hamster as a reinforcer may not be food for immediate consumption but food to pouch for hoarding.

The purpose of the present experiment was an examination of applicability of the matching law to this particular species. The relationship between the response rate and the reinforcement rate were expressed as a generalized matching law (Baum, 1974b) described as:

$$\text{Log}(B1/B2) = A \times \text{Log}(r1/r2) + B$$

where B1 and B2 are the response rates for two levers and r1 and r2 are the reinforcement rates obtained. Strict matching means that A equals 1.0 and that B equals 0.0. There are two types of deviation from the strict matching. When A is less than 1.0, the deviation is called undermatching. Undermatching means insensitivity to changes of relative reinforcement frequency, that is, the animals respond on a less reinforced lever more often than expected from relative frequency of reinforcement. When A is more than 1.0, the deviation is called overmatching. This means oversensitivity to changes of relative reinforcement rate whereby animals prefer a rich lever more than expected from the relative frequency of reinforcement. B gives a bias of responding. If animals have some preference for one lever regardless of frequency of reinforcement, B deviates from zero. The response pattern of hamsters was analyzed using the generalized matching law described above.

METHOD

Animals

Two male and one female experimentally naive golden hamsters (*Mesocricetus auratus*) were used. They were 6 months old at the start of the experiment and were maintained at 80 percent of their free-feeding weights. The room temperature was approximately 22° C throughout the experimental period. Illumination of the cage room was via a 12 h light-dark cycle.

Apparatus

The apparatus was an operant chamber (20 x 30 x 20 cm) designed for hamsters. There were two response levers 10 cm apart on the front

panel. The distance from the floor to the lever was 1.5 cm. A 25 gm weight would activate the levers. A pellet dispenser, which delivered a 40 mg pellet (Muromachi Kikai), was located at the center between the levers. There was a miniature lamp (24V, DC) on the ceiling of the chamber. A random noise generator (Rion, SF-05) continuously produced white noise (70 dB), and a microcomputer system (Sanyo, MSX+) determined the experimental contingencies.

Procedure

The hamsters were first shaped to press either lever. Then, a Variable Interval (VI) schedule with a single lever was introduced. During the single lever training, the unused lever was covered with a plastic box. The value of the VI schedule gradually increased to VI 30 s. After the hamsters showed stable responding on either lever, training on a Concurrent Variable Interval - Variable Interval (Conc VI-VI) schedule began. A changeover delay (COD) of 2 s was introduced into this concurrent schedule whereby a reinforcer on one lever was not available until 2 s had elapsed from the last response on the other lever. The daily training session lasted 30 min.

Table 1 shows the value of the concurrent schedule. The animals received Conc VI-VI training with a COD for 5 to 7 sessions. Stability of responding was evaluated using the relative number of responses to lever 1 (the left lever), calculated by dividing the number of responses to lever 1 by the total number of responses to both levers. When the animals did not show stable responding during the initial 5 or 7 sessions, the training was prolonged until fluctuations of the relative response measure remained less than 10 % for 3 successive sessions. The schedule value was then changed to the next one. However, one animal (M3) changed to the next schedule without satisfying this criterion due to the high variability of its responding. Pouching was determined and recorded after each daily training session. The pellets were not removed from the pouch.

RESULTS

Table 1 shows the number of sessions for each schedule value and the range of variability in the final three sessions of each condition. Mean response rates for one lever in the final three sessions on conc VI30"- VI30" was 4.81 / min, 3.87 / min and 9.34 / min for M1, M3 and F3 respectively. Each animal pouched the pellets obtained during

TABLE 1

Schedule values and number of sessions. L and R indicate the left and the right levers respectively. The number in brackets indicates range of percentage fluctuations of relative responding to the left lever over the total responses in the final three sessions.

M1			M3			F1		
L	R	Sessions	L	R	Sessions	L	R	Sessions
30	90	5 (3)	10	30	5 (6)	30	10	7 (5)
30	10	6 (18)	90	30	7 (3)	30	90	13 (2)
30	30	24 (26)	30	30	9 (9)	30	30	6 (9)
10	30	6 (7)	30	90	7 (3)	90	30	6 (5)
90	30	7 (3)	30	10	7 (2)	10	30	6 (2)

the daily training sessions. They were not seen to eat the pellets in the operant chamber but instead consumed them after they came back to their living cages.

Figure 1 shows mean relative responding in the final three sessions of each schedule value. The results support the generalized matching law. The r^2 value for the regression was between 0.82 and 0.99. The value of A was less than 1.0 for each hamster, so that they showed undermatching. F1 preferred lever 2 (the right lever) but the other animals did not show a strong bias.

DISCUSSION

The present results clearly demonstrated successful expansion of the generalized matching law to choice behavior of hamsters. The slope of the regression (0.87 for the three animals) was similar to data obtained from pigeons (0.84 for 137 birds, Baum, 1974b). Undermatching has been observed in most of the experiments on the matching law (Baum, 1979; Wearden & Burgess, 1982). The present results support this general tendency.

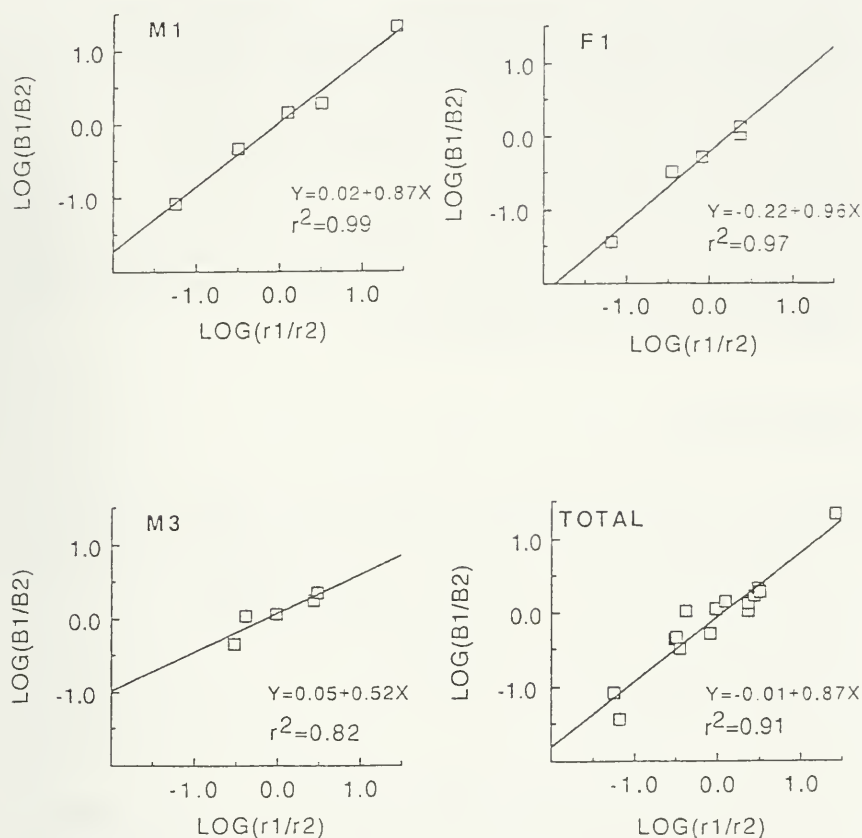


Figure 1. A generalized matching law analysis of choice behavior in three hamsters on Conc VI-VI schedules. B1 and B2 indicate response rates on the left and the right levers respectively. r_1 and r_2 indicate reinforcement rates obtained from each lever. The equations are those of the best-fitting straight lines obtained by the method of least squares.

In conventional operant conditioning with food reinforcement, there is a behavioral link between the presentation of food and its consumption. This link operates without interruption in conventional operant experiments with rats or pigeons. On the other hand, the particular feeding behavior of hamsters produces a delay between obtaining food and its consumption. Shearon and Allen (1989) suggested the existence of schedule induced pouching in hamsters. Thus, the pouching observed in the present experiment may have been facilitated by the schedule itself. The observation that three hamsters showed pouching in all training conditions suggests the applicability of the matching law to operant behavior in animals with this particular

consummatory behavior pattern. There are two possible explanations for the matching relation maintained by pouching. First, pouching may function as a conditioned reinforcement because hamsters obtain the primary reinforcer after pouching. This explanation, however, does not provide a reason for pouching. An alternative explanation is that the emission of pouching behavior itself is reinforcing for hamsters. Emission of innate behavior, such as aggression, has reinforcing effects in fighting fish (Thompson, 1963) and fighting cocks (Thompson, 1964). For hamsters, it could be conclusive to remove pouched pellets after completion of their daily training sessions.

REFERENCES

- Baum, W.M. (1974a). Choice in free-ranging wild pigeons. *Science*, *185*, 78-79.
- Baum, W.M. (1974b). On two types of deviation from the matching law: Bias and undermatching. *Journal of the Experimental Analysis of Behavior*, *22*, 231-242.
- Baum, W.M. (1979). Matching, undermatching, and overmatching in studies of choice. *Journal of the Experimental Analysis of Behavior*, *32*, 269-281.
- Gallistel, C.R. (1969). The incentive brain-stimulation reward. *Journal of Comparative and Physiological Psychology*, *69*, 713-721.
- Herrnstein, R.J. (1970). On the law of effect. *Journal of the Experimental Analysis of Behavior*, *13*, 243-266.
- Houston, A. (1986). The matching law applies to wagtails' foraging in the wild. *Journal of the Experimental Analysis of Behavior*, *45*, 15-18.
- Hutton, L., Gardner, E.T., & Lewis, J. (1978). Matching with a key-peck response in concurrent negative reinforcement schedules. *Journal of the Experimental Analysis of Behavior*, *30*, 225-230.
- Liewellyn, M.E., Iglauer, C., & Woods, J.H. (1976). Relative reinforcer magnitude under a nonindependent concurrent schedule of cocaine reinforcement in rhesus monkeys. *Journal of the Experimental Analysis of Behavior*, *25*, 81-91.
- Matthews, L.R., & Temple, W. (1979). Concurrent schedule assessment of food preference in cows. *Journal of the Experimental Analysis of Behavior*, *32*, 245-254.
- Phillips, J.H., Robinson, A., & Davey, G.C. (1989). Food hoarding behavior in the golden hamster (*Mesocricetus auratus*): Effects of body weight loss and hoard-size discrimination. *Quarterly Journal of Experimental Psychology: Comparative and Physiological Psychology*, *41B*, 33-47.
- Rashotte, M.E., & Smith, J.C. (1984). Operant conditioning methodology in the assessment of food preferences: Introductory comments. *Neuroscience and Biobehavioral Review*, *8*, 211-215.
- Shearon, T.O., & Allen, J.D. (1989). Schedule-induced pellet pouching in the golden hamster. *Bulletin of the Psychonomic Society*, *27*, 355-357.
- Thompson, T.I. (1963). Visual reinforcement in Siamese fighting fish. *Science*, *141*, 55-57.
- Thompson, T.I. (1964). Visual reinforcement in fighting cocks. *Journal of the Experimental Analysis of Behavior*, *7*, 45-49.
- Wearden, J.H., & Burgess, I.S. (1982). Matching since Baum (1979). *Journal of the*

Experimental Analysis of Behavior, 38, 339-348.

Wong, R. (1984). Hoarding versus immediate consumption of food intake among hamsters and gerbils. *Behavioural Processes*, 9, 3-11.

