Matching as a group phenomenon¹

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Prior to training on a .70-.30 positional learning problem, 16 rats showed their initial positional preferences on trials on which both left and right responses were reinforced. At asymptote, individual Ss differed with respect to tendencies both to over- or undermatch and to follow the reward, and both these tendencies were related to the Ss' initial positional preferences. No S maximized.

Most investigators of probability matching have supposed that when Ss match they do so as individuals. Indeed, Estes (1957) cited evidence of probability matching in rats as providing strong support for the validity of a statistical learning model which predicts that individual Ss will match. More recently, however, Bitterman (1965), maintaining that rats normally maximize rather than match, indicated that in the experiment which Estes reported the rats matched only as a group, individual rats reaching different asymptotes. Weitzman (1967), in an experiment on positional learning, showed that when rats and fish matched as groups individual Ss reached significantly different asymptotes.

Why Ss match as groups but not as individuals is the principal question which the experiment reported here attempts to answer. Secondary though logically prior questions which this experiment attempts to answer are whether the group matching which some of Weitzman's rats showed is a replicable phenomenon and whether when rats match they do so, as Bitterman (1965) suggested, by following the reward.

Method¹

Subjects, Apparatus, and Food. The Ss were 16 male Wistar rats aged approximately 60-90 days at the start of the study. Training was conducted in a Skinner box (Grason-Stadler Rat Station, Model E31258-100) with two levers mounted on one wall equidistant from a food tray so placed that S had to leave a lever to obtain food. The interior of the Skinner box was illuminated by two 7-W bulbs mounted behind translucent white glass screens located slightly above and to the right and left of the right and left levers, respectively. Light from a 25-W lamp 5 ft away was admitted through a circular window in a chest enclosing the Skinner box; this window allowed E to observe S during training. Reinforcement consisted of single 45 mg Noyes pellets. All experimental operations for which E was responsible were automated.

Pretraining. After 11 days of habituation to a 22 h deprivation schedule, followed by six days of magazine training, S underwent nine 20-trial days of lever-press training during which responses to both levers were reinforced. The lever to which S responded on more than half of the trials during the last five of these days was considered to be his preferred lever.

Training. For training, Ss were assigned to one

or the other of two main groups. Defining correct responses as responses reinforced on 70% of the trials each day, Group-1 Ss were trained so that responses to their preferred lever were correct, and Group-2 Ss were trained so that responses to their nonpreferred lever were correct. Assignment of Ss to Group 1 or 2 was random with the restriction that the proportion of to-be-correct responses on the last five days of lever-press training be as close to 0.50 as possible for the combined groups. The obtained value was 0.47.

A total of 400 training trials was given, 20 trials per day. Guidance procedure was used. Each trial began with both levers illuminated. A response to one lever turned out both lights and produced reinforcement. A response to the other lever turned out the light over that lever, leaving the light on over the first lever. Subsequent responses to the second lever had no effect, but a subsequent response to the first lever turned out the remaining light and produced reinforcement. Only the first response on each trial was counted.

During both training and pretraining, each reinforce-

Fig. 1. Learning curves of Groups 1 and 2 and total group. Day-0 values are proportions of to-be-correct responses on 100 trials just prior to training; on these trials, both left and right responses were reinforced.

Table 1. Data for Individual Subjects and Total Group

Rat	Side	Correct response		z for asymptotic reward following test ^c
		Initial preference ^a	Asymptote ^b	
1	Right	.02	.32	-1.69
2	Right	.02	.70	5.93
3	Left	.41	.75	-0.71
4	Left	.49	.62	-0.67
5	Right	.00	.43	1.72
6	Right	.68	.62	2.61
7	Left	.93	.74	-2.06
8	Right	.00	.68	2.14
9	Right	.82	.92	0.11
10	Left	.97	.85	-1.83
11	Right	.00	.61	3.88
12	Right	.49	.85	-0.98
13	Left	.91	.77	0.33
14	Left	.82	.80	1.16
15	Left	.92	.73	-1.11
16	Left	.01	.85	-1.73
Average		.47	.70	

^aEach entry is proportion of to-be-correct responses on 100 trials just prior to introduction of differential reinforcement.

^bEach entry is proportion of correct responses on last 200 trials with differential reinforcement.

^c $z > 1.65$ indicates reward following; $z < -1.65$ indicates reward anti-following; $-1.65 < z < 1.65$ indicates no significant tendency to follow or anti-follow the reward.

ment was accompanied by a 1 sec time out when both lights remained off and no responses were reinforced.

Results

Over the last 200 trials, the proportion of correct responses was, for all Ss, .70; for Group 1, .77, and for Group 2, .64. Because the variance as well as the number of correct responses varies from day to day prior to asymptote, a two-tailed nonparametric (rather than parametric) test for upward or downward linear trend (Still, 1967) was applied to the number of correct responses per day over the last 200 trials, the results being for Group 1 $N=7$ and $T=7$, for Group 2 $N=9$ and $T=11$, and for the total group $N=16$ and $T=60$. Since all these values of T are well within the 90% acceptance region, it is reasonable to conclude that for each group the responses over the last 200 trials were asymptotic and that, therefore, the total group matched, Group 1 overmatched, and Group 2 undermatched.

Figure 1 shows that the learning curves for Groups 1 and 2 never cross. The probability that on the last 10 days, at asymptote, the Group-2 curve will *without crossing* remain below the Group-1 curve if there is only a chance difference between the curves is less than .001 ($p=2^{-10}$). Examination, in Table 1, of the initial preference and asymptote for each S shows that one S in Group 1 undermatched and three Ss in Group 2 overmatched; however, the one-tailed Fisher probability (Siegel, 1956) for this result was only .05, indicating that the number of misclassified

Ss was not enough to justify ascribing the difference between Groups 1 and 2 to chance.

The Ss differed with respect to reward following. For each S at asymptote, a two-tailed, large-sample, difference-between-independent-proportions test was applied to the proportions of correct responses following reinforcements of correct and incorrect responses. The results, which appear in Table 1, show that at asymptote Ss 2, 5, 6, 8, and 11 tended to follow the reward, Ss 1, 7, 10, and 16 tended to do the opposite, and Ss 3, 4, 9, 12, 13, 14, and 15 seemed to behave randomly with respect to reward following. The same test applied to the preasymptotic data for each S, however, indicated that all Ss but one tended to follow the reward prior to asymptote.

Asymptotic reward following, like mean asymptotic behavior, was related to initial preferences. Of 10 Ss with initial preferences of less than .10 or more than .90, eight were asymptotic reward followers or anti-followers; of the remaining six Ss, only one was a reward follower or anti-follower at asymptote. The one-tailed Fisher probability for this result was .02.

Discussion

The hypothesis that initial positional preferences remain partially isolated from the effects of training can explain the results of both this and previous experiments showing group matching if it is assumed that in the previous experiments Ss were assigned randomly and hence in approximately equal numbers to groups corresponding to Groups 1 and 2. Because of continuing positional preferences, these groups respectively over- and undermatched, the Ss in the two groups together showing an average but not an individual tendency to match.

The results of this experiment are somewhat at variance with the predictions of both Estes (1957) and Bitterman (1965). According to Estes, individual Ss must match, but the Ss in this experiment matched only as a group. According to Bitterman, nonmaximizing rats should follow the reward; however, in this experiment, whereas all but one of 16 rats tended to follow the reward prior to asymptote, at asymptote—though no rat maximized—only five rats tended to follow the reward. Altogether, the reward-following results of this experiment are perplexing and would seem to require replication prior to speculation.

References

- BITTERMAN, M. E. Phyletic differences in learning. *Amer. Psychologist*, 1965, 20, 396-410.
- ESTES, W. K. Of models and men. *Amer. Psychologist*, 1957, 12, 609-617.
- SIEGEL, S. *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill, 1956.
- STILL, A. W. Use of orthogonal polynomials with nonparametric tests. *Psychol. Bull.*, 1967, 68, 327-329.
- WEITZMAN, R. A. Positional matching in rats and fish. *J. comp. physiol. Psychol.*, 1967, 63, 54-59.

Note

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