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EFEITO DA DURAÇÃO RELATIVA DOS ESTÍMULOS REFORÇADORES EM ESQUEMAS CONCORRENTES COM DIFERENTES DENSIDADES DE REFORÇOS: UMA REPLICAÇÃO SISTEMÁTICA DE DAVISON (1988)

EFFECT OF RELATIVE REINFORCEMENT DURATION IN CONCURRENT SCHEDULES WITH DIFFERENT REINFORCEMENT DENSITIES: A REPLICATION OF DAVISON (1988)

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ABSTRACT

Previous studies have challenged the prediction of the Generalized Matching Law about the effect of relative, but not absolute, value of reinforcement parameters on relative choice measures. Six pigeons were run in an experiment involving concurrent variable-interval schedules with unequal reinforcer durations associated with the response alternatives (10 s versus 3s), a systematic replication of Davison (1988). Programmed reinforcement frequency was kept equal for the competing responses while their absolute value was varied. Measures of both response ratios and time ratios showed preference for the larger duration alternative and that preference did not change systematically with changes in absolute reinforcer frequency. Present results support the relativity assumption of the Matching Law. It is suggested that Davison's results were due to uncontrolled variations in obtained reinforcement frequency.

Keywords: choice, preference, overall reinforcer frequency, reinforcer magnitude, pigeons.

RESUMO

Estudos anteriores têm questionado a predição da Lei Generalizada da Igualação sobre o efeito do valor relativo, e não absoluto, de parâmetros de reforçamento sobre medidas relativas de escolha. O presente estudo utilizou seis pombos em um experimento em que esquemas concorrentes de intervalo variável foram programados com diferentes durações do estímulo reforçador associadas a cada alternativa (10 s *versus* 3 s de acesso). A frequência programada de reforços foi mantida constante para as respostas alternativas, enquanto o valor absoluto foi manipulado. Medidas de distribuição de respostas e de tempo alocado aos esquemas mostraram preferência pela alternativa com maior duração do reforço, e essa preferência não foi sistematicamente afetada por mudanças na frequência absoluta de reforços. Os resultados apoiam a formulação da Lei da Igualação em termos de medidas relativas. Sugere-se que os resultados de Davison foram afetados por variações assistemáticas na frequência de reforços obtidos.

Palavras-chave: escolha, preferência, frequência de reforços, magnitude de reforços, pombos.

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Responding in concurrent variable-interval schedules of reinforcement (VI) where the components of the concurrent pair differ in frequency and magnitude of reinforcement is described by the Generalized Matching equation

$$\log (B_1/B_2) = \log k + a \log (R_1/R_2) + b \log (A_1/A_2) \qquad (1)$$

where B is a measure of response or time, R and A denote reinforcer frequency and magnitude, respectively. Subscripts indicate the two schedules, a and b are empirical parameters indicating sensitivity to reinforcement frequency and magnitude, and k is bias, a possible constant proportional preference for one schedule due to variables other than those being manipulated (Baum, 1974; Lobb & Davison, 1975). The independence of ratios of rate and magnitude of reinforcement in choice situations was suggested by Baum and Rachlin (1969). Independent changes in the reinforcement frequency and magnitude parameters of Equation 1 were demonstrated by Schneider (1973), Todorov (1973), Todorov, Hanna and Sá (1984), and Davison and Baum (2003), among others, but not replicated by Keller and Gollub (1977), Elliffe, Davison and Landon (2008) and Aparicio, Baum, Hughes and Pitts (2016).

Equation 1 considers only relative values of reinforcer frequency and reinforcer magnitude, implying that the equality holds for any absolute values of those parameters, with the value of the sensitivity parameter depending on the type of the independent variable being manipulated (cf., de Villiers, 1977; Herrnstein, 1970; Rachlin & Laibson, 1997; Staddon & Cerutti, 2002; Williams, 1988). Davison (1988), however, pointed out some data that would challenge that assumption: Davison & Hogsden (1984) and Logue & Chavarro (1987) presented data showing that the sensitivity to reinforcer magnitude was not constant but rather depended on the absolute values of the durations. Davison (1988) kept constant, but different, reinforcer durations, along changes in the absolute reinforcement frequency of equal variable-interval concurrent schedules, and reported systematic changes in the sensitivity to reinforcement magnitude. He concluded that the Generalized Matching Law has serious problems in describing changes in preference for an independent variable when that variable is changed: "... concurrent-schedule preference between different reinforcer durations may not be independent of the overall frequency with which the reinforcers are produced" (Davison, 1988, p. 345).

However, the experiments reported by Logue and Chavarro (1987) and by Davison (1988) had in common deviations from programmed equal reinforcer frequencies resulting in unscheduled obtained unequal relative reinforcement rates (Todorov, 1991; Todorov, Coelho & Beckert, 1993). The present experiment replicated Davison's procedure, correcting the programming of dependent concurrent variable-interval schedules (Stubbs & Pliskoff, 1969), following Davison's suggestion that "rather than speculation about models, what is required now is a considerable amount of empirical research to chart in a more detailed fashion the effects of relative and overall reinforcer durations, and the interactions between these in their effects on choice" (Davison, 1988, p. 347). The present experiment was a replication of Davison (1988) with one change. In order to avoid systematic deviations between scheduled and obtained relative reinforcement rates, the order and number of reinforcers associated with each schedule was predetermined by a computer program.

METHOD

Subjects

Six male adult pigeons, of an uncontrolled derivation of the species *Columba Livia*, experimentally naive, were maintained at 85% of their free-feeding body weights by feeding varying amounts of grain immediately after the daily training sessions.

Apparatus

Three sound attenuated experimental chambers (Grason Stadler Model E315AA-3), in which noise was masked by exhaust fans, were situated in a sound attenuated room, adjacent to the location of controlling equipment. Two response keys 9 cm apart, 2 cm in diameter, 21 cm from the grid floor, requiring about 0.1 N for their operation, were situated in one wall of the chamber. The left response key was transilluminated by a red light, the right key by a green light. A white light was located on the ceiling, and was turned off during reinforcements, when the feeder was then illuminated by red or green light. A food hopper was situated midway between the keys and 10 cm from the floor. Reinforcements were periods of access to mixed grain. During reinforcements, the hopper light was on, all other lights were off, and programming and recording devices stopped. A BBC Master computer scheduled and recorded events.

Procedure

Subjects were submitted to dependent concurrent variable interval, variable interval (*conc* VI VI) schedules (Stubbs & Pliskoff, 1969) in which the absolute frequency of reinforcements was varied while relative reinforcement frequency was kept constant, with equal VI schedules associated with each alternative. This aspect of the procedure was the fundamental difference from that used by Davison (1988). Dependent concurrent schedules was a procedure devised by Stubbs & Pliskoff (1969) to avoid uncontrolled deviations of obtained from programmed reinforcement distributions (*cf*., Shull & Pliskoff, 1967). The order and number of reinforcements to be obtained in each schedule was controlled beforehand by a computer program considering the programmed session duration. A 3-s changeover delay (COD; Herrnstein, 1961) was in effect after changeovers. Experimental sessions run seven days a week. Daily sessions ended after 60 reinforcers had been

obtained or after 45 min had elapsed, whichever event occurred first. Each experimental condition (see Table 1) was in effect until a stability criterion had been met, at which point the condition was changed for that subject. The initial criterion was that the median relative response rate on the left key over five sessions was not more than .05 different from the median over the immediately preceding five sessions, given a minimum of 14 sessions per condition.

Table 1.
Sequence of Experimental Conditions, VI Schedules, and Reinforcer Durations.

Experimental Condition	VI Schedules (s)	Reinforcer Duration (s)	
		Left	Right
1	120	10	3
2	30	10	3
3	60	10	3
4	120	10	3
5	180	10	3
6	240	10	3
7	240	3	10
8	30	3	10
9	16	3	10
10	16	10	3

Note: Equal VI VI schedules on both components of the concurrent schedules

RESULTS

Figure 1 shows the logarithm of response ratios (left response/right response) and time ratios as a function of total obtained reinforcer frequency in the last five sessions of experimental conditions for each bird. Conditions with 10 s reinforcement duration programmed on the left are presented on the left panels and conditions with 10 s reinforcement duration on the right are shown on the right panels. Data are summarized in the Appendix.

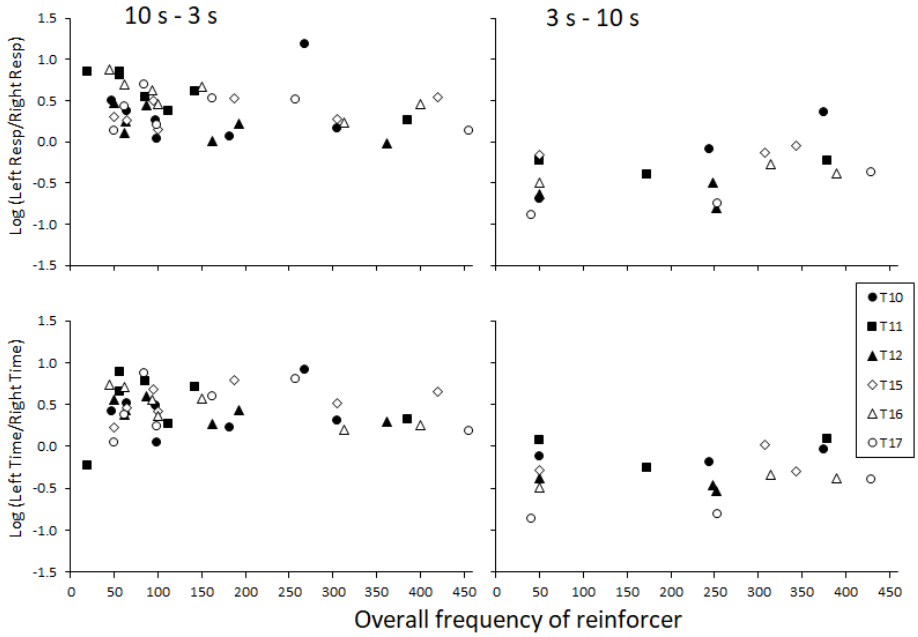

Figure 1. Response ratios and time allocation ratios (log) as a function of overall obtained reinforcer frequency of each condition.

Visual inspection shows that response and time allocation ratios did not change systematically with changes in overall frequency of reinforcement for all subjects. Table 2 shows R^2 and slope of regression analysis for individual data relating response ratio or time ratio to overall frequency of reinforcement. Ratios of all conditions were calculated with 10 s reinforcer duration as numerator and 3 s as denominator.

Variations of choice behavior measures were not explained by changes in overall frequency of reinforcement and increases in one behavior were not followed by systematic decreases in absolute reinforcement rate. Coefficient of

determination (R^2) for response and time of all subjects were, in general, below 0.2, except for T11 and T15. In addition, slopes of regression analysis were 0.00, indicating no trend for all 12 functions between choice behavior and absolute reinforcement rate. Group analysis (Figure 2) with average data showed also slopes close to 0.00.

Table 2.
R^2 and Slope of Regression Analysis for Individual Data.

Bird	Response		Time	
	R2	Slope (*a*)	R2	Slope (*a*)
T10	0.1279	-0.0016	0.1281	-0.0013
T11	0.3317	-0.0018	0.2630	-0.0017
T12	0.0613	0.0009	0.0506	-0.0007
T15	0.2271	-0.0011	0.1361	-0.0012
T16	0.1472	-0.0012	0.0864	-0.0008
T17	0.0175	0.0004	0.0156	0.0004

Note. Equation $\log(B_{10s}/B_{3s})$ or $\log(T_{10s}/T_{3s}) = a.(R_{total}) + b$
B=response; T=time allocation; R_{total}= total obtained reinforcer frequency

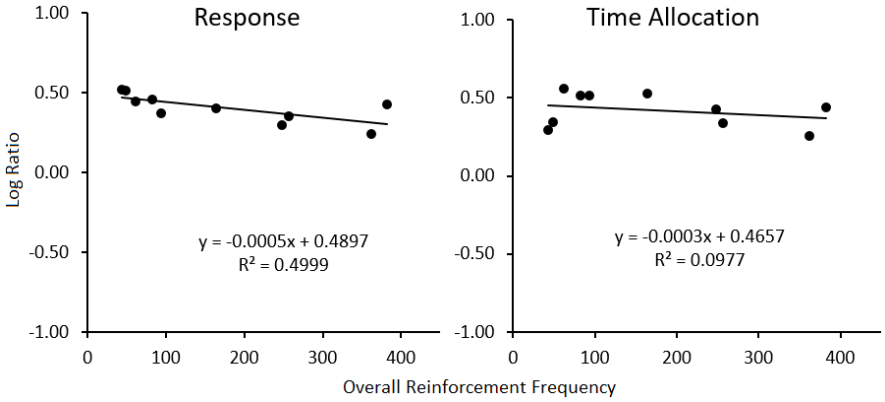

Figure 2. Response ratios and time allocation ratios (average data of all subjects) as a function of overall obtained reinforcement frequency.

DISCUSSION

Results of the present experiment showed that changes in choice behavior (response and time ratios) varied with changes in reinforcement duration, but not in overall reinforcement frequency of reinforcement, both for individual and group data. These results are inconsistent with Davison's conclusion (1988) regarding the effect of absolute reinforcement frequency on response and time distributions controlled by unequal reinforcer amounts scheduled for the alternative schedules of a concurrent pair.

The present data suggest that the uncontrolled variations on relative reinforcement frequency observed on Davison's (1988) data may be responsible for the differences observed in his study (Todorov, 1991). When scheduling of reinforcers between choice alternatives depends on probability generators, the obtained relative frequency may vary from the prediction based on a fixed probability, especially when the sample is small. When a sample is made of 60 events, for example, a generator that is accurate for samples of at least 1000 events may result in distortions as those observed in Davison's experiment.

A replication of Davison's (1988) experiment was important because of its implications for the theory behind the Matching Law (Herrnstein, 1961, 1970). The matching equation predicts the relation between relative measures, without mention to absolute values. The conditions under which the relativity assumption holds are still a topic for research (*e.g.*, Aparicio et al., 2016). The present results suggest that two other related experiments should be replicated, Davison and Hogsden (1984) and Logue and Chavarro (1987).

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APPENDIX

Sum of data from the last five sessions of each experimental condition showing number of responses on the left response key, responses on the right key, time associated with the left key and with the right key, and reinforcers delivered after responses in each key.

Bird	Condition	Responses		Time (s)		Reinforcers	
		Left	Right	Left	Right	Left	Right
T10	1	8830	8235	6792	6033	49	50
	2	7531	5253	7717	3739	153	152
	3	8866	7748	7731	4550	91	91
	4	7716	4207	9729	3121	47	50
	5	10381	4337	10006	3037	34	30
	6	5100	1632	9580	3609	22	25
	7	1606	7838	5694	7458	25	25
	8	3383	4178	4500	6918	122	122
	9	4568	1990	5284	5705	186	189
	10	9834	643	10439	1279	133	135
T11	1	9631	1367	10761	2354	29	27
	2	5110	2138	8328	4422	56	56
	3	13151	3234	10470	2076	69	73
	4	11291	3203	11047	1865	44	41
	5	15474	2431	11607	1494	30	26
	6	4101	578	5017	8367	7	12
	7	5657	9635	7166	5977	25	25
	8	1923	4852	4382	7952	86	87
	9	3935	6661	6016	4946	188	191
	10	7516	4127	7440	3503	192	194
T12	1	1736	999	9563	3500	33	30
	2	2302	1408	8963	3262	95	97
	3	2410	2361	8099	4312	81	81
	4	2846	1034	10316	2586	45	42
	5	2277	1766	9254	3825	31	31
	6	4619	1543	10304	2867	24	25
	7	809	3461	3838	9318	25	25
	8	1060	3282	3019	8831	125	123
	9	391	2490	2706	9110	124	128
	10	1651	1720	7463	3763	180	182

Bird	Condition	Responses		Time (s)		Reinforcers	
		Left	Right	Left	Right	Left	Right
T15	1	12215	3881	10661	2189	47	47
	2	8156	4330	8794	2676	154	151
	3	8771	2600	10528	1713	94	93
	4	8913	6345	9293	3522	50	50
	5	4915	2688	9679	3366	34	30
	6	6570	3249	8209	4941	25	25
	7	4121	5963	4478	8675	25	25
	8	4701	6347	5910	5558	154	153
	9	3296	3672	3749	7457	172	172
	10	10556	3016	8689	1919	210	210
T16	1	15369	5450	8918	3893	50	50
	2	10922	6358	7005	4392	156	157
	3	12223	2607	9837	2649	75	75
	4	15266	3604	10064	2797	46	47
	5	15774	3223	10915	2154	31	30
	6	12235	1633	11156	2053	20	24
	7	4310	13608	3235	9914	25	25
	8	6894	12866	3617	7781	155	159
	9	4345	10624	3174	7717	193	197
	10	9781	3431	6967	3870	200	200
T17	1	11581	2305	11413	1507	43	41
	2	7176	2193	10211	1586	126	132
	3	13822	4131	9913	2493	81	81
	4	12997	8230	8168	4659	49	50
	5	12991	4781	9259	3821	32	30
	6	8415	6127	6896	6256	25	25
	7	1586	12362	1601	11632	17	23
	8	2793	15823	1596	10208	125	128
	9	5483	12696	3082	7537	214	216
	10	9727	7231	6362	4164	226	230