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SOME PARAMETERS AFFECTING THE DISTRIBUTIONAL PROPERTIES OF OPERANT-LEVEL RUNNING IN RATS[1]

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Six adult female albino rats were subjected to operations known to increase the frequency of wheel-running. Operations included limited access to wheel, food deprivation, and protracted maintenance on a 24-hr feeding schedule. A distributional analysis of response duration, burst duration, and inter-burst interval showed that the increased frequency in all cases arose mainly from a shortening of the interval between successive bursts. Only short-term food deprivation produced any notable increase in burst length, and even here changes in both speed of the individual responses and in number of responses per burst were slight compared to changes in inter-burst interval.

A number of operations including food deprivation, spatial confinement, drugs and external stimulation are known to increase the frequency of wheel-running in rats (Reed, 1947), but the specific locus of the increase is not known. Increased frequency could come from (*a*) increased speed of individual responses, (*b*) reduced inter-burst interval (IBI), (*c*) increased burst length (BL), (*d*) combinations of the above; and each operation could produce its increase in a different manner. In view of the large number of operations that affect wheel running, a more detailed analysis of locomotion presents the appealing opportunity to collect and perhaps isolate the operations on the basis of their effect upon the specific distributional properties of running. The present experiment examined the effect of several parameters upon the total frequency and distributional properties of rat locomotion in the activity wheel.

METHOD

Subjects and apparatus

Six female albino rats (*S*s), Sprague-Dawley strain, ca 200 days old were used. The apparatus was four Wahmann activity wheels instrumented to record each 180° of turn. The wheels were operated by approximately 35 in g force, and could be turned in both directions. Animals were housed individually in the small cage attached to each wheel, and access to the wheel was controlled by a sliding door between the cage and wheel. The wheel assemblies were housed in sound-deadened, light-tight, ventilated cabinets, illuminated by 15-w overhead house lamps.

Procedure

The *S*s were adapted to the wheels until running stabilized (12 to 18 days), then tested on a series of conditions involving differential access to food and wheel; free food and wheel was the base condition to which *S*s were intermittently returned. The conditions in the order of their occurrence were as follows: free food and wheel; restricted wheel, free food; free food and wheel; restricted food and wheel; extended feeding schedule, restricted wheel; free food and wheel. Three daily test sessions were given on each condition. The restricted wheel condition allowed access to the wheel daily from 8 to 9 a.m. The restricted food condition allowed access to food daily from 11 to 12 a.m. The extended feeding schedule consisted of maintaining the *S*s on the restricted food condition for 14 days; *i.e.*, *S*s were so maintained prior to being tested on the wheels. Moreover, following the wheel test *S*s were returned to the cage rack and maintained on free food for 14 days before being

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Table 1
Number of Wheel Turns in 1-Hr Session

	Condition					
	A	*B*	*A*	*C*	*D*	*A*
Food Condition:	Free	Free	Free	Restricted	Extended Restricted	Free
Access to Wheel:	Free	Restricted	Free	Restricted	Restricted	Free
Subject						
1	45	138	15	216	279	78
2	150	296	29	418	339	158
3	553	887	556	1527	938	441
4	78	262	121	301	422	141
5	100	293	59	347	427	98
6	72	396	132	340	420	149
Mean	166.33	378.67	152.0	524.83	470.83	177.5

retested on the base condition of free food and wheel. This handling of the extended feeding schedule was aimed at maximizing its effect, and, subsequently, assuring recovery from it.

In all test conditions the house light was turned off daily from 7 a.m. to noon, and running was recorded daily from 8 to 9 a.m. by remote counters and an Esterline Angus operations recorder. Room temperature was maintained between 76 and 78° F.

RESULTS

A "response" was defined as one complete wheel revolution, primarily because few wheel turns of less than 360° occurred. A "burst" was defined as one or more successive responses separated by less than 2.5 sec from any preceding response.

Frequency. Table 1 shows the number of responses made per session for the six periods averaged over the three sessions given per condition. Relative to the base condition of free food and wheel, frequency was increased by restricting access to the wheel, further increased by 24-hr food deprivation, but not notably increased beyond that and in some cases reduced by a 14-day feeding schedule.

Distributional properties. Response duration was found to be largely constant, as in a previous study (Premack and Schaeffer, 1962); over 90% of all wheel turns took approximately 1 sec.

The distributions for both burst length (BL) and inter-burst interval (IBI) were positively skewed, as in the previous study (Premack and Schaeffer, 1962), and are not shown here. Figure 1 presents mean IBI (upper panel), and mean BL (lower panel), both plotted over conditions, with separate curves for each *S*. Although the scale for IBI is in seconds, and that for BL in number of responses per burst, it is nonetheless possible to compare IBI and BL. Most responses took about 1 sec. Therefore, burst length can be read as burst duration, and the scale for BL read approximately in seconds, and thus compared directly with IBI. When making this comparison note that, relative to BL, the IBI scale is greatly compressed, *i.e.*, equal distances on the two ordinates entail a far greater change in IBI than in BL.

The main point shown in Fig. 1 is that the increased frequency, for all conditions and all *S*s, came primarily from a reduction in the average IBI. That is, shortening of the pauses between successive bursts of running accounted for most of the increased frequency in all conditions. Only a small part of the increment is attributable to an increase in BL. Furthermore, whereas all incremental conditions led to a reduced IBI, only one condition—short-term food deprivation—produced any appreciable increase in BL. Thus, when restricted in access to the wheel, half of the *S*s showed no increase in average BL, and five of six had a longer average BL after only one day than after 14 days of the feeding schedule.

The *S*s differed somewhat in the extent to which changes in IBI and BL accounted for changes in frequency. For example, *S*-3 showed the greatest amount of change in BL of all *S*s and the least in IBI, and vice versa for *S*-1. Yet even *S*-3, which showed less change in IBI than any other *S*, showed more change

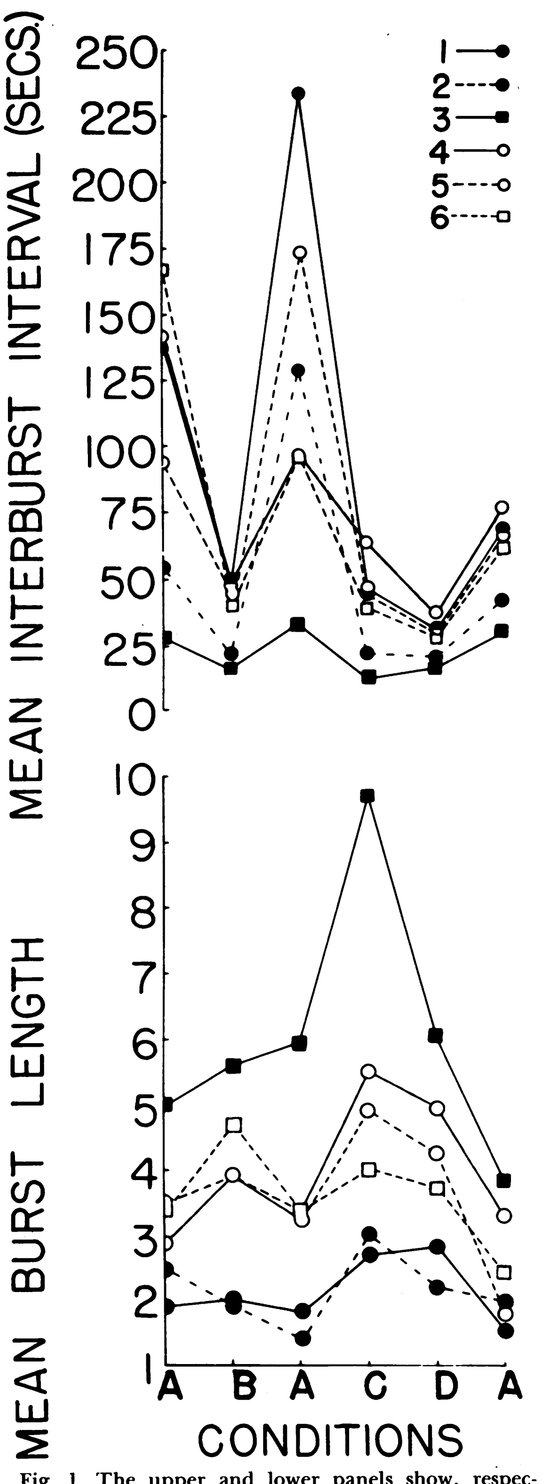

Fig. 1. The upper and lower panels show, respectively, mean inter-burst interval and mean length of burst for each animal for each of the conditions. A is the base condition of free food and wheel; B is free food, restricted wheel; C is restricted food and wheel; and D is extended-restricted food and restricted wheel.

over the six conditions in IBI (about 14-35 sec) than in BL (about 4-10 sec).

DISCUSSION

The greater contribution of average IBI to changes in frequency indicates that the incremental conditions affected mainly the probability that, if not running, *S*s would *start* running. In contrast, the relative constancy of mean BL indicates that if *S* was running, the probability that it would *stop* varied little with the several conditions. Sidman and Stebbins (1954) have reported what appears to be at least partly comparable results for fixed-ratio food-contingent bar pressing, where food satiation increased pause time but had little effect upon momentary bar-press rate. A theory of what stops on-going behavior might consider, as a first approximation, simply number of responses that have previously occurred in the burst. Even as a first approximation, however, a theory of what starts behavior must allow for a mechanism that is differentially sensitive to even the relatively few parameters that were tested here.

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