were 10.4, 12.9, 18.8, 21.3, and 26.3, respectively. The fit of these values to Stevens's power law is excellent. The method of magnitude estimation thus seems capable of operating on brief stimuli varying in both luminance and duration (*11*).

DAVID H. RAAB

Department of Psychology, Brooklyn College, Brooklyn, New York

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Prenatal Influence on Behavior of Offspring of Crowded Mice

Abstract. Pregnant albino mice were subjected to stress by crowding. When the litters encountered unfamiliar stimuli, they were less active, they were slower to respond, and they defecated less than control mice. These differences persisted at 30 and 100 days of age, whether the mice were raised by a crowded or by an uncrowded mother, and in spite of starvation. One explanation may be that aberrant endocrine activity in the crowded, pregnant female impairs the development of fetal response systems.

Everyone has heard the old wives' tale that guarantees a musically talented child to pregnant mothers who listen to Beethoven. Some recent findings are in harmony with this view, suggesting that prenatal environment may in fact influence postnatal behavior. Thompson (*1*), for example, found that rats which fear an electric shock deliver anxious pups. Their offspring need more time to leave a cage spontaneously, cover less ground when they do, and after starvation take longer to discover food than animals from normal mothers. In the experiments reported here, comparable results were found when pregnant mice were crowded.

Even when living space is varied from 1 to 42 square feet, Christian and others (*2*) have found similar increases in the adrenal weights of mice as population rises. Christian also noted significant differences in the reproductive activity of both sexes when he compared crowded groups of 20 with uncrowded groups of two. With Christian's procedure used as a guide, 15 female albino mice were crowded in a wooden cage, 6 by 12 by 5½ inches. Uncrowded control mice lived five to a cage of the same dimensions.

With parturition imminent, a pregnant mouse was segregated to deliver and raise her litter alone. To control for postnatal influences due to weaning, some crowded mothers were translocated so that they could nurse a litter born to an uncrowded female. Likewise control mothers were exchanged. A female and her litter were kept as units in uncrowded cages from birth until the time of testing. Food and water were supplied freely.

Behavior was investigated by recording the time which elapsed before a single mouse left its cage spontaneously. A wire mesh ramp in the cage allowed free access to a table. Response latency was measured from the time the wire ramp was installed until the moment the animal stepped from the ramp by putting all four feet on the table. Thus, the first mouse to leave the ramp was called the fastest mouse. Every litter had its own fastest mouse, second-fastest mouse, third-fastest, and so on, for which response times were separately recorded. The intention was to eliminate biases produced by any hierarchies of dominance or leadership, or both.

Latency was recorded with respect to five independent variables: (i) litter born to crowded or uncrowded (control) mother; (ii) age of 30 days versus 100 days; (iii) 1½ days of starvation before first latency test; (iv) 1½ days of starvation before second latency test; and (v) reciprocal translocation, where litters born to crowded or uncrowded mothers were raised by uncrowded or crowded mothers, respectively.

For all variables, test and control groups came from different litters. But control mice used with the first variable also served as the controls for the fourth; test groups for these variables were used in a similar manner. Thus, 15 of 75 litters (or 94 out of 479 mice) were examined with more than one variable.

Behavior was also examined by noting defecation in a previously unexperienced environment. This was measured for 100-day-old mice and for animals whose mothers were translocated. Each mouse was lifted by the tail from its cage and placed on a clean, black table. After 5 and 10 minutes, the number of pellets dropped by the litter was observed.

The results of the latency tests are summarized in Tables 1 and 2. In Table 3, the defecation results are listed.

Litters from crowded mothers were less active and slower to respond to unfamiliar stimuli than control groups born to uncrowded mothers. These differences were found whether the mice were raised by a crowded or by an uncrowded mother, at 30 days and at 100 days of age, and in spite of starvation. If the stimuli were familiar, however, hunger overrode other disturbances and few significant differences were found in the responses of starved animals.

At age 100 days, litters from crowded mothers defecated less than controls when placed in an unfamiliar environment. This also occurred at age 30 days in litters born to crowded mothers but raised by uncrowded females. A tendency for increased inhibition as a result of translocation and disturbance is evident, as in the latency tests, but the tendency is slighter and not statistically important.

Realistically, we expect that behavior is liable to both prenatal and postnatal effects, and some of these experiments may not separate the two. For example, at age 100 days, we may wonder why the difference in response latency fails to persist and why a significant variation in total activity makes its first appearance. Also, inadvertent differences in handling or social experience may have occurred. The fact that total activity dropped sharply when a litter was not raised by its own mother points even more clearly to strong postnatal modifications of response.

However, nursing and other postnatal modifications will not abolish behavior traits acquired *in utero*. Mice born to crowded mothers, but raised by uncrowded nurses, differ very little except in the amount of response from mice born to and reared by their own crowded mothers. Those that respond at all are just as slow in their sponta-

Table 1. Average time in minutes needed for mice to leave cage spontaneously. All groups were 30 days old, except where asterisk denotes 100-day-old groups. Symbols: U, litters from mothers uncrowded during pregnancy; C, litters from crowded mothers. S, starved 1½ days before first latency test; 2S, starved 1½ days before second latency test. U-C, offspring of uncrowded mother raised by crowded nurse; C-U, the reciprocal of U-C. N, not significant; *P*, probability, less than .05 by nonparametric tests.

Variable	Fastest mouse			Second-fastest			Third-fastest			Fourth-fastest		
	N	Time	*P*	*N*	Time	*P*	*N*	Time	*P*	*N*	Time	*P*
					Group 1							
U	11	8.99	.05	6	5.51	.01	4	7.86	.05	4	16.06	N
C	10	16.28		5	18.58		1	13.50		1	17.08	
					Group 2							
U*	9	6.38	N	8	11.98	N	6	13.54	N	5	14.97	.01
C*	8	11.32		5	16.05		3	17.77		2	26.44	
					Group 3							
U-S	10	1.72	N	10	2.50	.05	10	5.19	.01	10	8.47	N
C-S	10	2.45		10	5.99		10	11.75		7	12.47	
					Group 4							
U-2S	5	1.33	.05	5	3.58	N	5	5.83	N	4	5.27	N
C-2S	10	3.02		10	3.82		10	8.29		9	11.18	
					Group 5							
U-C	2	1.25	.01	0			0			0		
C-U	3	13.03		2	15.54		0			0		

Table 2. Total activity of groups and average litter size at time of testing. Symbols are explained in legend of Table 1.

Variable	Litters tested (No.)	Mice per litter (Av. No.)	*P* value for size difference	Mice tested (No.)	Mice that left cage		*P* value of activity difference
					No.	%	
				Group 1			
U	11	7.27	N (.25)	80	32	40	N
C	10	6.10		61	17	28	
				Group 2			
U*	9	6.33	N	57	32	56	.05
C*	9	6.00		54	19	35	
				Group 3			
U-S	10	6.50	N (.2)	65	64	98	.01
C-S	10	5.70		57	44	77	
				Group 4			
U-2S	5	6.60	N	33	32	97	N
C-2S	10	6.10		61	59	97	
				Group 5			
U-C	7	7.29	N (.1)	51	2	4	N
C-U	9	6.00		54	4	9	

Table 3. Defecation of mice in an unfamiliar location: average number of pellets dropped per litter after 5- and 10-minute periods. Symbols are explained in legend of Table 1.

Variable	Age (days)	No. pellets after 5 minutes	*P*	No. pellets after 10 minutes	*P*
		Group 2			
U*	100	26	.01	38	.01
C*	100	12		20	
		Group 5			
U-C	30	14	.05	26	.05
C-U	30	4		13	

neous behavior; their survival rates are as far below normal; and their defecation is equally limited when compared with that of 100-day-old mice whose mothers are not translocated.

The animals face an unfamiliar situation as their spontaneous activity and defecation are measured. To satisfy the activity task, mice run from their sawdust cage floor, across a wire mesh ramp, and onto a smooth table. Again in the defecation tests, the familiar cues of the home cage are replaced when the animals are moved gently onto a table.

Spontaneous activity (*1, 3*) and defecation (*4*) have long been considered susceptible to an emotional influence. With the animals surrounded by unfamiliar stimuli, it was thought that their behavior patterns would be vulnerable to this kind of influence and that performance differences would be clearer. Such a point of view implicates the physiological systems which control social and psychological behavior.

If these physiological mechanisms suffer aberrant embryonic development, then perhaps there is reason for these findings. Once the stress associated with high population density mobilizes the endocrine defenses, abnormal levels of circulating maternal hormones might endanger the fetal glands. Evidence of an endocrine rapport between mother and child exists even for humans, for the majority of children born to hyperthyroid women are thyroxin-deficient (*5*). Should hormonal function in the mouse embryo be equally sensitive, then while the mother could respond perfectly well to high density stress, her offspring could not (*6*).

KIM KEELEY*

Yale University,
New Haven, Connecticut

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* Present address: Cornell University Medical College, New York, N.Y.

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