

BRIEF REPORT

Effects of Olfactory Experience on Aggression in *Mus musculus* and *Peromyscus maniculatus*¹

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Groups of *Mus musculus* and *Peromyscus maniculatus* were raised from birth either in the presence or absence of odors of the other species. In later tests of interspecific aggression it was found that individuals raised in the presence of the odor of nonconspecifics won more encounters than did members of groups raised only with conspecific odors.

The effects of experience on the social behavior of rodents has been examined by a number of investigators. Denenberg *et al.* (1963) found that mice cross-fostered to rats were less aggressive among each other as adults than mice raised by conspecifics. Quadagno and Banks (1970) found that *Mus* cross-fostered to *Baiomys* preferred to be close to *Baiomys* in later tests. The importance of early olfactory experience was demonstrated by Marr and Gardner (1965) who showed that young rats rubbed with cologne starting early in the nursing period later preferred the company of conspecifics rubbed with that cologne over normal conspecifics.

The acuity of olfaction in mice was shown by tests in which white mice quickly discriminated conspecifics by odor alone (Kalkowski, 1967). The importance of olfaction in aggressive behavior was shown by Ropartz (1968) who found bulbectomized mice exhibited no aggression while controls showed a high level.

In another area of research, King (1957) found that in encounters between *Mus musculus* and *Peromyscus maniculatus bairdi*, *Mus* individuals

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were much more aggressive. King suggested that if their niches overlapped, *Mus* would be able to drive *Peromyscus* away.

The following preliminary experiment was an attempt to measure effects of olfactory experience upon aggressive behavior in *Mus musculus* and *Peromyscus maniculatus*.

Two species of mice were used: a strain of *Mus musculus* long inbred in the laboratory and of several colors (white, gray, brown, and black) and *Peromyscus maniculatus bairdi*, inbred in the laboratory for a number of generations but retaining the wild-type color pattern. Pregnant females were obtained from the Mammalian Genetics Center of the University of Michigan.

All experimental animals were raised from birth in one of three olfactory environments: (1) a room containing only *Peromyscus* litters, therefore only *Peromyscus* odors; (2) a second, separate room containing only *Mus* litters; and (3) a third, separate room containing both *Mus* and *Peromyscus* litters. The litters were held in metal mouse boxes (17.5 × 27.5 × 12.5 cm) with wood shavings on the floors and grated tops, immediately adjacent to each other to permit mixing of smells. Food and water were *ad libitum*. In the room containing litters of both species, the boxes were arranged with equal distances between boxes containing conspecifics and boxes containing members of the other species. The boxes prohibited mice from seeing any activity in adjacent boxes, tactile or gustatory exchanges were not possible.

Peromyscus litters were weaned at 32-39 days, *Mus* at 33-37 days. At weaning, the males of each species were separated from the females and placed in groups of two or three (*Mus*) or three or four (*Peromyscus*) in boxes identical to those in which they had been nursed. Each postweaning box contained males from two or more litters. The groups were left in the same rooms as they had been nursed in so the olfactory environments remained similar during nursing and postweaning periods.

Encounters were started at 53-59 days for *Mus* and 58-64 days for *Peromyscus* and ended at an age of 87-93 days for *Mus* and 92-98 days for *Peromyscus*. Encounters were run in one of two, identical 40 × 40 × 40-cm boxes, each with a Plexiglas front for observation and a sliding plywood partition. The plywood surfaces of the boxes had been coated with marine shellac to facilitate cleaning. After each encounter, a box was wiped carefully with 70% isopropyl alcohol and allowed to air dry while the other observation box was used for the next encounter. With the dividing partition in place, a mouse was placed in each half of the box and allowed to adapt for 5 min. The partition was then lifted and the encounter observed for 10 min. Numbers of fights, severity of fights, and number of submissive postures (Grant and Mackintosh, 1963) shown were recorded as indices of aggressive behavior. All animals were weighed immediately following the final testing period.

Experimental animals were in four groups: (1) *Peromyscus* raised with only *Peromyscus*, (2) *Mus* raised with only *Mus*, (3) *Mus* raised with both species, and (4) *Peromyscus* with both species. These groups resulted in ten different types of encounters (e.g., a *Mus* raised only with *Mus* vs. a *Peromyscus* raised with both *Mus* and *Peromyscus*). To minimize effects of the order in which a mouse fought each type of mouse, a round-robin scheme for encounters was followed. In encounters involving two mice of the same type (e.g., *Mus* raised with *Mus* vs. *Mus* raised with *Mus*), the animals were taken from different boxes.

The results of all the encounters are given in Table 1. The category "hard fights" includes interactions characterized by sustained chasing, long, hard bites, or a series of nips in rapid succession by the winning mouse. "Weak fights" include encounters won by a single, short nip.

Mus raised with the odor of both *Mus* and *Peromyscus* won a much larger proportion of their encounters (of those decided one way or another) with *Peromyscus*, than *Mus* raised with only *Mus*. "*Mus* with both" won 74% of their interspecific encounters while "*Mus* with *Mus*" won only 32% (chi square = 5.17, $p < .025$). Similarly, *Peromyscus* raised with the odor of both species won a greater proportion of decided encounters with *Mus* (65%) than *Peromyscus* raised with only conspecifics (33%). This difference, however, is not significant (chi square = 3.71, $.10 > p > .05$).

The dominance of individuals raised with both species is also shown by the fact that of the 29 encounters that were decided involving one mouse raised with both species and one mouse raised with conspecifics only, in 24 the mouse raised with both was dominant (chi square 12.2, $p < .005$).

Mus and *Peromyscus* were of equal aggressiveness in interspecific encounters in this experiment (although *Mus* were heavier). Of 36 interspecific encounters that were decided, each species won 18.

Of those interspecific encounters that were decided by fights, *Mus* won nine by hard fights and seven by weak fights. *Peromyscus* won only two by hard fights and 12 by weaker fights (chi square = 3.99, $p < .05$). Also, in intraspecific fights, for *Mus* seven were decided by hard fights while three were neutral, whereas for *Peromyscus* none were decided by hard fights while seven were neutral (chi square = 7.34, $p < .01$).

On the average, the *Peromyscus* used in this experiment weighed only 59% as much as the *Mus*. The average weights for the two *Peromyscus* groups were the same (15.8 g) and the two *Mus* groups (26.5-g average *Mus* with *Mus*, 26.9 g *Mus* with both) did not differ significantly ($t = 0.31$, $p > .50$).

The most important result of these observations is that individuals of both *Peromyscus* and *Mus*, when raised in the presence of the odors (and sounds) of both species, won a higher proportion of their interspecific encounters than mice raised in the presence of only conspecific odors.

TABLE 1

Results of All Encounters. M = *Mus*, P = *Peromyscus*, and B = Both

Category Encounter	Category of Mouse	Won Hard Fight	Won Weak Fight	Other Submissive	Agonistic behavior But No Winner	No. fights Neutral
M w/M vs. M w/M	M w/M	5	0	2	0	1
P w/P vs. P w/P	P w/P	0	0	2	2	4
M w/M vs. P w/P	M w/M P w/P	3 1	0 2	1 3	1	5
M w/B vs. M w/M	M w/B M w/M	1 1	1 0	2 0	1	2
P w/B vs. P w/P	P w/B P w/P	0 0	3 0	0 1	1	3
P w/B vs. M w/M	P w/B M w/M	1 2	5 0	1 0	5	1
M w/B vs. P w/P	M w/B P w/P	4 0	6 1	0 0	4	0
M w/B vs. M w/B	M w/B	2	1	0	0	5
P w/B vs. P w/B	P w/B	0	3	1	1	3
P w/B vs. M w/B	P w/B M w/B	0 2	4 1	0 1	5	2

The results observed can be the consequence of one (or both) of two possible mechanisms: (1) that mice raised in the complex olfactory environment are more aggressive toward nonconspecifics, and/or (2) mice raised in the less complex environment are more "fearful" (therefore submissive) when in the presence of strange (olfactory) stimuli. It was observed, that in interspecific encounters, "with both" individuals clearly initiated 90% of the

interactions, while in only 10% of these encounters did the "with conspecifics only" individual show submission or retreat before any aggression by the other mouse.

Contrary to the findings of King (1957), that *Mus* won nearly all interspecific encounters with *Peromyscus*, in this experiment there was an even split in number of interspecific encounters won. However, size differences between the species in the present experiment make any comparison difficult. The higher level of aggressiveness in intraspecific encounters in *Mus* is consistent with King's data.

There were several factors in the present experiment which could not be controlled which qualify the strength of the results. Most important is the small number of animals available for the observations. Another complication is the different color forms of *Mus*. A third problem is the number of fights that each animal was involved in (from 8 to 16) and the possibility of fighting experience stabilizing the results of later interactions.

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