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Potential Stock Differences in the Social Behavior of Rats in a Situation of Restricted Access to Food

Rémi Helder,[1,3] Didier Desor,[1] and Anne-Marie Toniolo[2]

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The social behavior of outbred Long–Evans (LE) and Wistar (WI) rats was compared in a situation where access to food was particularly difficult (clearing an aquatic barrier, plus the necessity of carrying the food back to the home cage). In groups of either six WI or LE rats, only about 50% of individuals carried the food, and the others survived by attacking those that did. However, behavioral profiles associated with these acts were different in the two cases: LE carriers, contrary to WI carriers, restole some food, and LE noncarriers expressed more agonistic behavior and were more often attacked than were the WI noncarriers. Food flow and all associated, interactive behaviors were more complex in the LE than in the WI rats, indicating the likelihood of potential genetic differences in this testing situation.

KEY WORDS: Rats; stock comparisons; social behavior; food retrieval.

INTRODUCTION

The impact of genetic factors on various biological aspects of behavior has been evidenced in numerous comparative studies with rats, even those comparing non selected stocks (for some examples and reviews, see Ambrogi Lorenzini *et al.*, 1991; Aulich and Vossen, 1978; Creel, 1980; Jori *et al.*, 1971; Jurcovica *et al.*, 1984; McCarty *et al.*, 1984; Walsh, 1980). Several of these studies have included comparisons of albino Wistar (WI) and pigmented Long–Evans (LE) stocks. WI rats have, for example, been observed to consume more food than LE rats, whereas the latter showed an enhanced locomotor activity in wheel running tests (Ambrogi Lorenzini *et al.*, 1987, 1988).

Most of these studies, however, have described behavioral or physiological reactions of individual animals confronted by environmental challenges. In the area of pharmacological experimentation, interest in social behavior as an experimental model is growing. In this connection, the emergence of social differentiation has been previously described in groups of rats faced with an environmental constraint related to the accessibility of food, the so-called "Swimming Pool situation" (Colin and Desor, 1986; Thullier *et al.*, 1992; Deviterne *et al.*, 1994). As a first step toward determining whether genetic factors may play a role in that social differentiation, the present study compared groups of rats from WI and LE stocks in this test.

METHODS

Subjects

The 58 male, outbred Wistar rats used, housed in eight cages of 6 rats and two cages of 5 rats, were purchased from Iffa Credo Breeding Laboratory, France. The 53 male, outbred Long–Evans rats used, divided among eight cages of 6 rats and one cage of 5 rats, were obtained from Janvier

[1] Laboratoire de Biologie du Comportement et Physiologie-URA 1293, Université de Nancy I, B.P. 239, 54506 Vandoeuvre-les-Nancy Cedex, France. Fax: (33)83 91 24 18.
[2] Laboratoire de Psychologie, Université de Nancy II, Bv Albert 1er, 54015 Nancy Cedex, France.
[3] To whom correspondence should be addressed.

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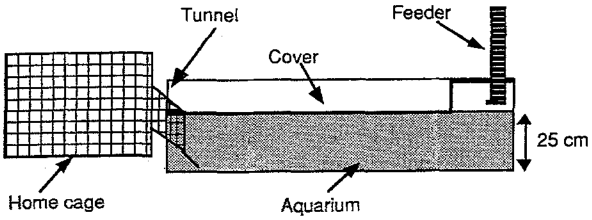

Fig. 1. Experimental setup.

Breeding Laboratory, France. The rats were 60 days old when they arrived at the laboratory. The temperature in the housing room was kept at 22°C, and a 12/12 light/dark cycle with lights on at 0700 h, was maintained. Water and standard laboratory diet were available ad libitum until the start of the experimental phase.

Apparatus and Testing Procedure

The device (Colin and Desor, 1986) was composed of a home cage (50×40×29 cm) connected by a tunnel to an aquarium (125×20×35 cm), at the end of which a single feeder is placed (Fig. 1). This device was designed to force the rats to dive and swim under water for a distance of 1 m and to make it nearly impossible to eat the food at the feeder, therefore forcing them to carry the food pellet (diameter = 10 mm; length = 25 mm; weight–2.5 g) back to the home cage. After a familiarization period with the device (on the first 2 days, there was no water in the aquarium), the progressive filling of the aquarium (7 days) began (successively 1, 2, 5, 10, 15, and 24 cm of water; 1 day at each height, except at 24 cm, 2 days) until the maximum water level (25 cm) was reached. From this day onward, the animal had to dive and swim underwater to the feeder and back to the home cage. The total duration of this journey (cage–feeder–cage) does not exceed 5–6 s, and the pellet's condition is not appreciably altered during the 2–3 s that it is underwater. The maximum water level phase lasted 21 days (water temperature, 19°C).

Throughout the experiment, access to the feeder was limited to a 3-h daily period and the rats did not have any other source of food during the rest of the day. Water was available ad libitum. A total of 10 "swimming pools" was used, allowing five groups of WI and five groups of LE rats to be tested daily from 0800 to 1100 and five groups of WI and four groups of LE rats to be tested from 0100 to 0400.

Observations

On the basis of videorecordings, individuals were characterized by the following variables:

(1) the number of carryings performed,
(2) the amount of feeding time (measured in seconds) gained by carrying,
(3) the total number of thefts of food pellets committed,
(4) the amount of time spent feeding following the theft of food pellets,
(5) the total number of thefts from carrier rats,
(6) the total number of thefts from noncarrier rats,
(7) the total number of thefts endured, and
(8) the amount of feeding time lost due to the theft of pellets.

In addition to ascertaining that normal weight increases resume after the first week of the maximum water level phase (indicating the satisfactory acclimatization of the animals), previous observations (Colin, 1989) have determined that the differentiation in WI groups is very stable after the 14th day at maximum water level and that most food carrying (and consequently most interactions) occur during the first hour of each session. The data were therefore collected on the 21st day of the experiment, during the first hour of that session. At this time, all animals were 90–95 days old.

All the behavioral scoring was performed by the same, trained observer.

Statistical Procedures

Given that most behavioral variables did not follow Gaussian distribution, median, inferior, and superior quartiles were used as statistical parameters of central tendency and dispersion. For the same reasons, distribution free methods (chi-square and Mann–Whitney test) were used to compare the values of the various variables of the two stocks of rats.

RESULTS

To get a pellet, a rat had to cover the journey from the living quarters to the food distributor by

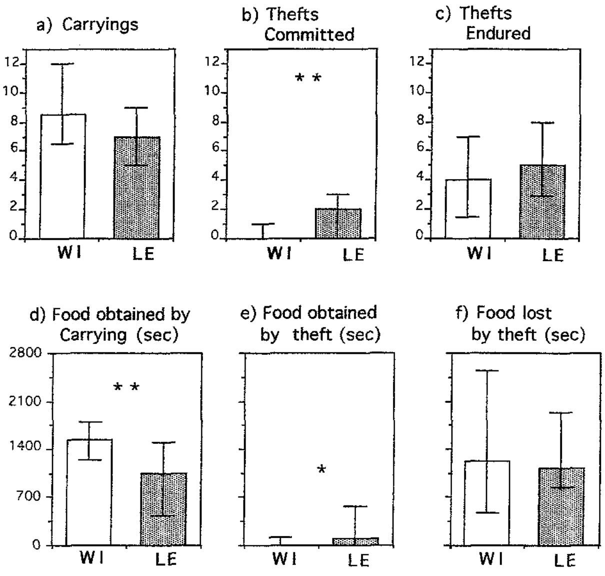

Fig. 2. Comparison (Mann–Whitney) between WI and LE carriers in terms of total numbers of carryings (a), total numbers of thefts committed and endured (b, c), feeding time obtained by carrying activity and theft (d, e), and food lost through theft (f). Data are expressed in medians and quartiles. (**) $p < .005$; (*) $p < .05$.

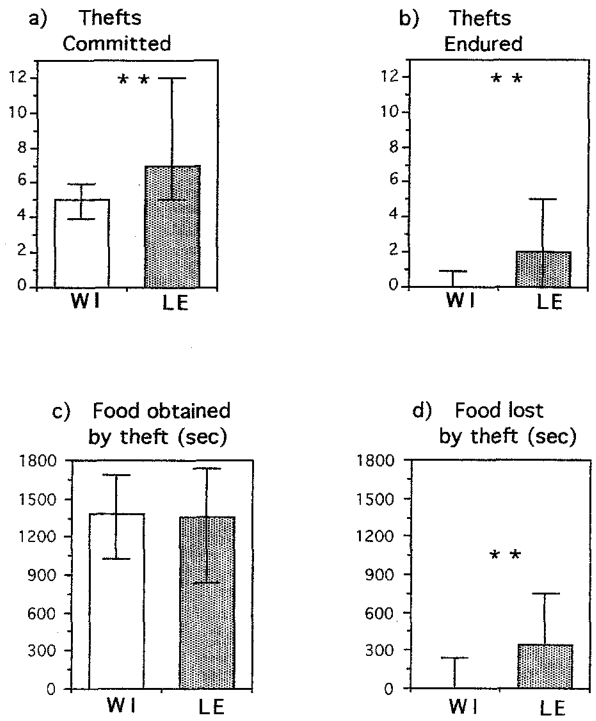

Fig. 3. Comparison (Mann–Whitney) between WI and LE noncarriers of thefts committed and endured (a, b) and feeding time obtained through theft (c) or lost through theft (d). Data are expressed in medians and quartiles. (**) $p < .001$.

diving into the aquarium. As it was impossible to consume the food there, it had to return to the cage. Studies published on this experimental model show that, among rats from the WI stock, the carrying of food from the food distributor to the habitation cage was only performed by a part of the population: the carriers. The others (the noncarriers) never made this journey. In the present study, noncarrier rats also appeared among the LE rats. Results showed a total of 28 carriers of 58 WI rats (48.3%) and 27 carriers of 53 LE rats (50.9%), this difference being not significant ($\chi^2 = 0.01$; NS).

Behavioral Profile of WI Rats

As can be seen in Figs. 2a–f, a typical WI carrier completed 8.5 return journeys between the cage and the pellet distributor during the first hour of the session. It generally committed no thefts. Instead, it fed exclusively on the fruits of its journeys, allowing a total of 1538 s of feeding time. The carriers only kept half of the food they carried. Of the 8.5 pellets collected, 4 were lost following thefts. The carrier had thereby supplied 1245 s of feeding to others in the habitation cage.

The noncarriers (Figs. 3a–d) showed a radically different strategy than that of the carriers: they stole food (median of committed thefts = 5) and retained it for themselves (median of endured thefts = 0). Furthermore, three-quarters of the noncarriers never stole from other noncarriers, preferring to steal from the carriers. Carriers, although the amount stolen was relatively small, tended to steal from other carriers.

Figure 4a indicates the percentage of intercategory thefts relative to the total number of thefts in the groups, during the observation period. The major flow (87.8%) appeared between the noncarriers (theft committing) and the carriers (theft endured). The remaining (12.2%) could be placed in three categories: between noncarriers (5.8%), between carriers (4.5%), and between the carriers (theft committing) and the noncarriers (theft endured) (1.9%).

Behavioral Profile of LE Rats

As can also be seen in Figs. 2a–f, a typical LE carrier performed seven return journeys between the cage and the distributor. This allowed it 1045 s of feeding. It had an added 108 s of feeding, as it stole food on two occasions. Food was stolen a total of five times from it and, consequently, it lost 1118 s of potential feeding time.

The noncarriers (Figs. 3a–d) obtained all their food by means of interactive behavior. The seven thefts they carried out yielded a total of 1356 s of feeding. Of the seven pellets obtained, two were lost through subsequent thefts, totaling a loss of 341 s of feeding per rat.

In comparison to WI rats, LE rats of both categories carried out thefts. A typical LE noncarrier committed 4.5 thefts on carriers and 1.5 on noncarriers. Furthermore, carriers conducted thefts on both categories of rats. Figure 4b indicates the percentage of intercategory thefts relative to the total number of thefts in the groups, during the observation period.

The majority of the interactions flow went from the noncarriers to the carriers, but this flow represented only 53.4% of the total number of thefts in the LE cages. The three other possible interactions represented more than 46% of the total number of thefts: 18.7% between noncarriers, 17.3% between carriers and noncarriers, and 10.6% among carriers themselves.

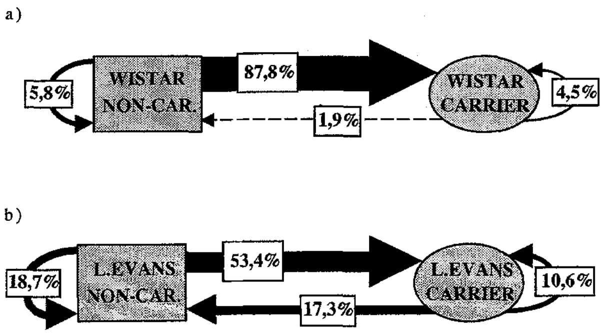

Fig. 4. Percentage of thefts committed in proportion to the number of thefts carried out by the WI (a) and LE (b) rats. The arrow points from the thief to the victim.

Table I. Comparison (Mann–Whitney) Between the WI and the LE Carriers and Between the WI and the LE Noncarriers, in Terms of Number of Thefts Committed Against Both Types

	Carriers, WI/LE	Noncarriers, WI/LE
Thefts committed toward carriers	$U=262.5$ $p<.05$	$U=363$ NS
Thefts committed toward noncarriers	$U=283.5$ $p<.05$	$U=171.5$ $p<.0001$

Comparing the Behavior of WI and LE Rats

As can be seen in Figs. 2a–f, the quality of supply did not differ in the carriers of either strain: the same numbers of thefts were committed against them ($U = 294$, NS) and they provided the same quantity of food to the habitation cage ($U = 351$, NS). However, the LE carriers were distinguished from their WI counterparts through more interactive behavior: they committed more thefts than the WI carriers ($U = 313.5, p < .05$). Such thefts compensated for their weaker carrying benefits ($U = 195, p < .005$).

With regard to Figs. 3a–d, it can be seen that the LE noncarriers were also more interactive than their WI counterparts. They carried out twice as many thefts ($U = 221.5, p < .001$). However, this supplementary interaction did not bring them any feeding benefits ($U = 370.5$, NS). These noncarriers were more often victims of interaction than the WI noncarriers ($U = 187, p < .001$), so they had to compensate for their loss of food by increasing their number of thefts ($U = 208, p < .001$).

Comparison of the Interaction Networks

Table I indicates that the increase in thefts by the LE carriers was directed toward both carriers and noncarriers alike. Although the LE noncarriers conducted, on the average, the same number of thefts against carriers as did their WI counterparts, the increase in interaction seen was directed mostly toward other noncarriers. Such differences led to a characteristic organization of food transfer for each stock. In the case of WI rats, on the majority of occasions a pellet was either kept by the carrier or stolen and kept by a noncarrier. Most of the transfers in any one cage were done between two individuals. On the contrary, in LE cages the same pellet might be exchanged several times. Most of the transfers were performed among three or four individuals in the same cage.

DISCUSSION

The food supply of both stocks of rats used in the present study was provided only by some of the individuals (carrier rats), with the percentages of carriers being almost identical (49% in the WI and 51% in the LE rats). Nevertheless, the behavior of the rats was different in the two stocks, leading to different interaction networks within the groups. In the WI rats, the carriers no longer displayed agonistic behavior but reinforced their transport activity. The noncarriers, on the other hand, adopted the opposite strategy: once agonistic behavior had been perfected, they optimized this behavior by attacking the carriers. That agonistic behavior was simply momentarily suppressed in the carrier rats, however, was indicated by the earlier finding that when new groups were formed using only previously differentiated carrier rats, new differentiations in carrier and noncarrier rats appeared (Colin, 1989). In contrast to WI, the LE carriers maintained an agonistic behavior and attacked both other carriers and noncarriers. As LE noncarrier rats appeared to be less efficient in defending their food, the result was an increase in the level of conflict within the habitation cage (341 thefts, in contrast to 156 among the WI rats) and much more active food transfer between individuals of different categories.

This study has, therefore, demonstrated potential genetic effects on the social behavior of rats in a situation of restricted access to food. The next step in this direction would appear to be to test for within-strain differences and/or similarities, in the manner of File and Vellucci (1979), by using WI and/or LE rats which have been provided by different suppliers. A further step would entail controlling for possible within-group variations in LE rats by testing each group on multiple days.

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