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Home base behavior of rats (*Rattus norvegicus*) exploring a novel environment

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When rats are placed in a novel environment, they alternate between progression and stopping: in the course of a session they stop briefly in many places, but in one or two places they also stop for very long periods. The place in which they stay for the longest cumulative time is defined as the rat's home base. In this place the incidences of grooming and of rearing are high and often the highest. In addition, the number of visits to the home base is typically the highest. Some rats establish a secondary base with similar properties to those of the main home base. The location of the base influences the mode of progression throughout the environment: progression away from base is slower and includes more stops than progression back. It is suggested that this paradigm may be used for the analysis of the spatial organization of locomotor behavior in neuroscience research.

INTRODUCTION

Perhaps the most conspicuous spatial regularity of exploratory behavior in rats and other mammals is the existence of a home site or a home base. In the wild, mammals have a home site to which they repeatedly return after exploring their home range or territory[4,14]. Several studies of exploratory behavior note that upon being introduced to a novel laboratory setting, animals establish a home base from which they repeatedly explore the remainder of the available space[2,5,18,19]. Some features of laboratory rat behavior at the home base have been established previously but not published[17]. Other features, relating to the mode of locomotion of rats when away from the home base, but in reference to its location, have been noted by Geyer[10]. If exploratory behavior is indeed organized in relation to the environment, then it must be organized in relation to some reference points. An animal's home base is perhaps the most plausible candidate for such a reference point.

In view of the potential significance of the home base in behaviors involving exploration, navigation, and spatial memory, the objective of the present study is to provide a laboratory-based analytical documentation of the phenomenon, in the behavior of tame wild rats (*Rattus norvegicus*), in a novel environment. The features of spontaneous home base behavior can be utilized by researchers as markers of home base location. Once this location is established, it can be used as a reference point in the measurement of behavior

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when away from the home base, in both intact animals and pathological or pharmacological preparations[9,11,12].

MATERIALS AND METHODS

Animals

This study is based on the behavior of 25 tame wild rats (*Rattus norvegicus*) born to rats caught in the wild or to first generation rats brought up in captivity. Upon delivery, neonates were removed from their mothers and placed for fostering in the nests of lactating laboratory females. From 15 days of age, infants were separated from foster mother and placed singly into separate cages (60 x 50 x 40 cm). Each rat was handled daily for a few minutes, until the day of the recording session. In the course of its ontogeny, each rat was allowed to explore a variety of environments. As part of the handling routine, rats were picked up from their cage by hand, placed in a novel environment, then collected again by hand, and placed back in their home cage. Rats were kept on a 14-h light/10-h dark cycle (lights-on at 06.00 h) and fed with standard rat pellets and apples. Recording sessions took place at the age of 4–12 months; rats weighed 250–400 g at time of recording.

Observation platform

Extensive preliminary observations of rats in a variety of novel environments, suggested that in order to minimize the effect of nearby objects on the form of the rat's paths of movement and on the location of places of stopping, the environment should be simple and homogeneous. On the other hand, if the environment is too homogeneous, once having started to ambulate, the rat does not stop until reaching the edge of the testing environment (see Discussion). Our testing environment was, therefore, homogeneous in terms of proximal objects, but structured in terms of distal stimuli. It consisted of a 160 x 160 cm horizontal glass platform, free of objects and walls, and installed 1 m above the ground and 60 cm away from 4 walls, each of a different colour and texture. To allow simultaneous videotaping of both side and bottom views of the rat, a large mirror was placed underneath the platform, adjacent to it, tilted at 4°. The bottom view allowed accurate evaluation of horizontal trunk orientation and of the direction of stepping of all 4 legs. The space between the edges of the glass platform and the mirror was closed with transparent mylar, preventing the animal from descending onto the mirror. Videotaping was performed under artificial room lights, and took place from a hide (only camera lens was visible to the rat). To examine the effects of glass, corners, artificial lights, and platform size on behavior, 3 groups of 4 rats each, were videotaped in 3 additional environments: (1) a circular wooden platform (radius = 120 cm), 1 m above ground; (2) a square wooden platform (300 x 300 cm), installed outdoors 1 m above the ground; and (3) a large outdoor yard (3 x 5 m) with sand floor and 4 brick walls.

Recording procedure

Before videotaping, the rat was taken out of its cage with a glove, and handled for 5 min. When it appeared to relax, it was returned to its home cage and several minutes later taken out again, this time with a bare hand. It was then placed gently into the center of the platform, and its behavior videotaped for 1 hour. Videotaping took place during the light phase (08.00–17.00 h) of the day–night cycle.

Data acquisition

Mapping of platform. Eight straight lines radiating from the center of the platform in a clockwise direction, defined — at 45° angular intervals — as 8 places on the edge of the platform (Fig. 1A). These places are designated by 8 successive numerals: 0 for middle of far edge, 1 for right far corner, 2 for middle of right edge, etc. Places located on platform's edge between the previously labelled 8 places are designated, also in clockwise direction, by 0′, 1′, 2′, etc. Places between center and edge are respectively labelled as 0″, 1″, 2″. This procedure yields the mapping presented in Fig. 1B. The distance between the markings of 2 adjacent places is 40 cm, a distance equal to twice the length of a rat's body (excluding tail). Places located away from edge are somewhat larger, to facilitate assessment of rat location when away

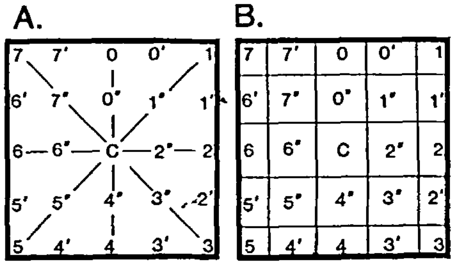

Fig. 1. Mapping of platform (160 x 160 cm). A: method of mapping (for explanation, see text); B: partitioning of platform to 25 places. Only signs of places were actually marked on the glass platform, to facilitate the assessment of rat's location. Light lines are drawn only in this figure, to indicate the subdivision to 25 areas. The areas of places were not equal. Those containing a corner were one-fourth as large, and those adjoining an edge were one-half as large as other places. When a rat walks or stops in proximity of an edge, it is characteristically attracted to the edge, staying quite close to it. The smaller size of rectangles along the edge is meant to take account of this regularity.

from edge. This mapping procedure is consistent with the Eshkol-Wachman method of mapping of topographical positions[8]; as such it allows using a somewhat similar mapping procedure for the description of both body movements and the spatial location of the animal.

Behavioral analysis. Time-coded videotapes were displayed on the screen at regular speed, and the places where the rat stopped were coded using custom programs that allowed the computer keyboard to serve as an event recorder. For each rat, the whole one hour session was recorded. Whenever the rat stopped, the observer pressed a key representing the place of stopping. The key pressed designated the place containing most of the rat's body at the time of stopping. The same key was pressed again at the time at which the rat left that place. Since time in the computer was synchronized with time on video record, a second program could calculate the sequence of stops, their duration, frequencies of stops in particular places, and cumulative durations of staying in each place. *Stopping* was recorded whenever there was a cessation of forward progression. In the present study, the term 'stop at a particular place' is used interchangeably with the term 'visit'. After recording the sequence of places in which a rat stopped, videotapes were replayed in slow motion, and the occurrence of grooming, rearing, and a particular type of pivoting around the forelegs, were recorded for each of the places. *Grooming* included either face grooming alone, or both face and body grooming. *Rearing* consisted of a vertical movement of the whole trunk including release of foreleg contact with the substrate. *Pivoting around forelegs* was comprised of whole body rotation (turning) around the vertical absolute axis located in the relatively stationary forelegs. Data collected consisted of single sessions, 1 hour duration each, of 25 rats (17 males and 8 females).

Statistics. Statistical comparisons were made using t-tests for independent or dependent samples, as appropriate. Indicated P-values are 2-tailed probabilities; accepted level of significance is $P < 0.05$.

RESULTS

I. Convergence of staying in place to one or two places in the environment

Upon being placed on the platform, rats alternate between progression and stopping. This is shown for one exemplary rat in Fig. 2. Intervals of stopping are represented by black bars, and intervals of walking from one place to the next are represented by the empty space between the bars. In this example, during the course of an hour, the rat stopped briefly in many places. In a few places, however, the periods of stopping were sometimes brief and sometimes very long.

According to the record, after 30 min, the rat changed the place in which it stayed for extended intervals. During the last 20 min of the session, the rat mostly alternated between two adjacent places (Fig. 2). Examination of the videotapes revealed that in this particular case, the alternation was an artifact of our recording procedure: the rat settled on the boundary between two predefined places, and, because of small shifts in its location of stopping, successive visits to the same physical location were recorded as visits to two separate (but adjacent) places. Since the rat stayed on the boundary, pivoting in place was also occasionally recorded as a shift to an adjacent place. This

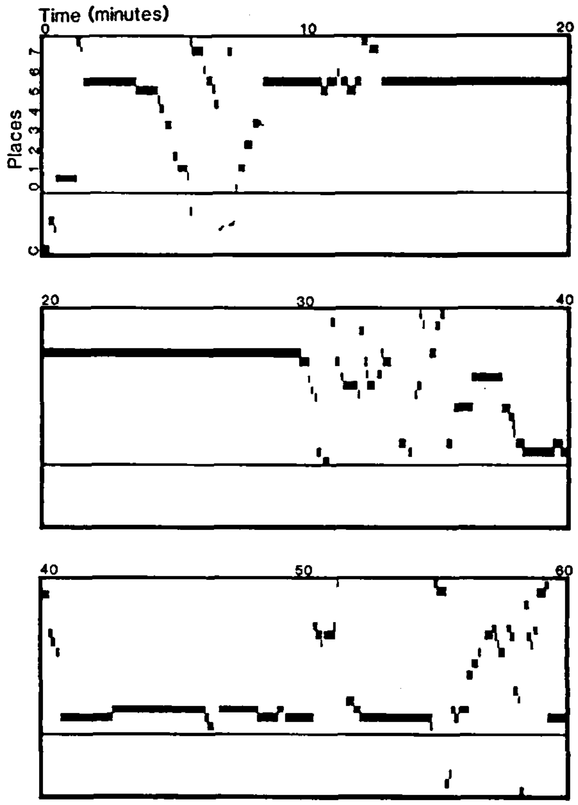

Fig. 2. A full chronological record of the places and durations of stopping, in the behavior of one rat in the course of one hour. The horizontal axis represents time; all the places on the platform are represented linearly on the vertical axis. The upper portion of each graph represents the places along the platform's edge; the lower portion represents the places located away from the edge. Heavy horizontal bar-lines represent staying in place. The empty horizontal spaces between bars represent movement from one place to the next. Because of space limitation, not all places are represented by numerals on the vertical axis: numerals represent places at 45° angular intervals; spaces between two successive numbers represent places between the previously labeled places (0′,1′,2′, etc., in Fig. 1); places in the middle of the platform (0″,1″,2″, etc.) are not printed on the vertical axis.

artifact of our recording method was taken into account in the following phase of data analysis.

The phenomenon of stopping for brief intervals in many places and for both brief and long intervals in few, selected places, is common to all rats. Fig. 3 presents 24 individual records of the places and durations of stopping in the course of one hour. For clarity of exposition, intervals of staying in place shorter than 20 s were eliminated from the record. As illustrated, most rats had one or two preferred places where they stayed for extended periods. The vast majority of stops which exceeded 20 s occurred in these places.

In the following sections we will first show that in rats there is one place that stands out from all the other places in the environment with respect to the cumulative time of staying in place, the frequency of grooming and rearing, and the number of visits to that place. We shall then examine the generality of this phenomenon by focusing on the behavior of each individual. Such examination reveals that some rats have only one preferred place, and some have two. Finally, we will show that progression away from base differs markedly from progression to base.

II. Convergence of behavior to home base

The duration and frequency of several behaviors are highest at the home base. More strikingly, these values represent another order of magnitude compared to the values at other locations. To show this statistically, two averages were compared (using paired *t*-test): the first average was based on values from all the 25 places on the platform, the second average was calculated for 24 places, without the home base data. A significant difference between the two averages implies that the home base data markedly biases the overall mean, and thus considerably differs from values at other places.

Cumulative time of staying in place

Home base location was defined as the place where the rat spent cumulatively the largest amount of time (Fig. 3). A paired *t*-test of the two averages obtained for each rat revealed that inclusion of home base data (highest value of cumulative time) in the calculation, biases the average significantly (Table I). Application of the same test to the second place does not yield a significant difference (Table I). Based on this result, it may be concluded that the place in which the rat stayed longest, also differs *markedly* from other places on the platform in terms of the time spent in it.

Grooming

In 22 out of 25 rats, the place in which the rat stayed for the longest time, and which was defined

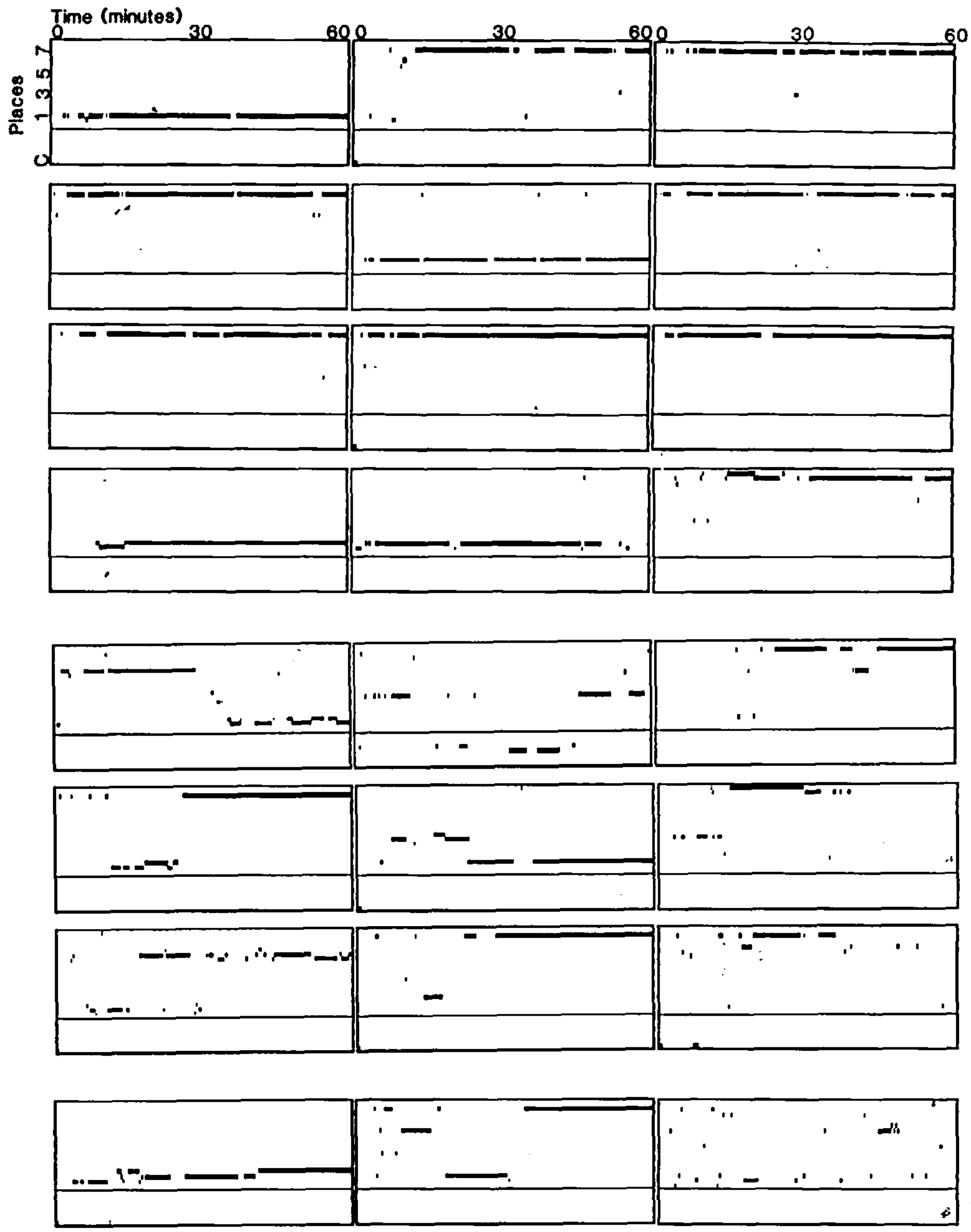

Fig. 3. A chronological record of the places and duration of stopping in the behavior of 24 rats, in the course of an hour. Stops shorter than 20 s were eliminated from record. Explanation as in Fig. 2. The four upper horizontal rows represent the records of 12 rats with one home base. The 4th row in this group represents the behavior of rats whose one home base happened to be located on the boundary between adjacent places. Rows 5,6,7 represent 9 rats with two bases. The bottom row represents 3 exceptions: a rat whose home base happened to lie on the boundary between 3 adjacent places (left); a rat with 3 non-adjacent places (middle); and a rat whose base locations were difficult to assess. The record of the 25th rat (a single base rat) is not represented because of space limitation.

by us as the rat's home base, is also the place where it groomed most often in the course of the hour session.

A comparison of the two averages of grooming incidence per place across the 1 hour of observation — one based on all places where grooming was performed, and the other excluding home base incidences — showed that the first average

TABLE I

Four measures of home base behavior across 1 hour

Each measure is the mean (± S.D.) of 25 rats. (1) Time (in s) of staying in place (cumulative); (2) incidence of grooming; (3) incidence of rearing; (4) incidence of visits. The values in column X1 are the means calculated, including only the places where the indicated behavior was performed. The value in column X2 was calculated similarly, but without behavior performed at home base. Values in column X3 were calculated similarly as for column X1, but without the second highest place of cumulative time. t-value was obtained for a paired t-test, and P is the (2-tailed) probability. As shown, for each measure of home base behavior, the difference between X1 and X2 is significant, whereas the difference between X1 and X3 is not significant.

Behavior	*X1 ± S.D.*	*X2 ± S.D.*	*t*	*P*	*X3 ± S.D*	*t*	*P*
Time	161 ± 31	51 ± 31	13.637	<0.001	120 ± 12	0.79	n.s.
Grooming	3.7 ± 2.3	1.5 ± 1.0	3.861	=0.02	3.0 ± 3.2	0.32	n.s.
Rearing	3.4 ± 1.8	2.4 ± 1.4	4.546	<0.001	3.0 ± 1.7	0.08	n.s.
Visits	6.3 ± 3.7	5.8 ± 3.6	11.682	<0.001	6.0 ± 3.5	0.20	n.s.

is higher. Based on these results, it may be concluded that the place where a rat stayed cumulatively for the largest amount of time coincided with the place where it groomed most frequently. The home base thus markedly differs from other places in terms of time spent, and incidence of grooming.

The high proportion of grooming at home base (number of grooms at home base out of number of grooms in all places), might reflect the proportion of time spent there. These proportions would have been equal, had the performance of grooming been equiprobable in and away from home base. Since most rats ultimately settle at a home base and stay there in relative arrest, the longer the session, the more biased is the ratio of proportions toward relatively higher proportions of time of staying at home base. To avoid a bias which may stem from the length of the recording session, we eliminated from our next calculation both the intervals of staying in place longer than 100 s, and the grooming bouts performed during these intervals. Periods of active locomotor behavior were then defined as periods in which a

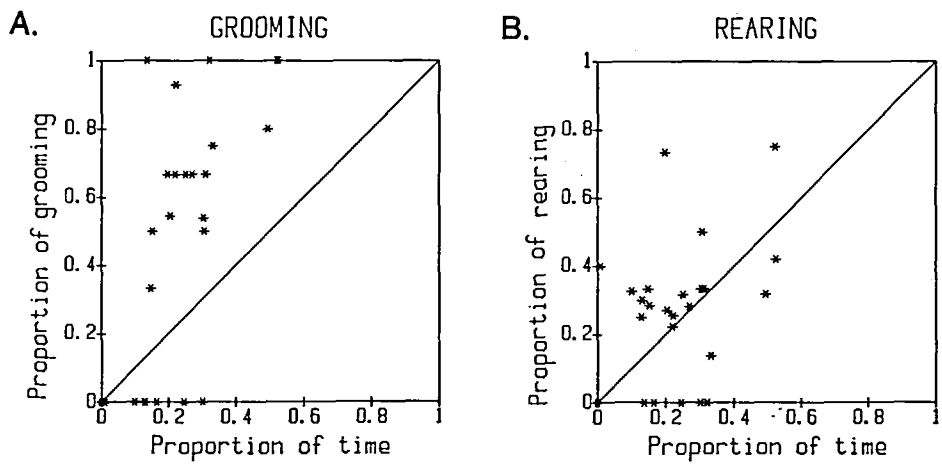

Fig. 4. Proportion of grooming (A), and rearing (B), at home base, in relation to proportion of time spent at home base during periods of active locomotor behavior. Asterisks represent individual rats. A: the proportion of grooming equals the incidence of grooming at the home base during stops shorter than 100 s, divided by the total incidence of grooming during stops shorter than 100 s. The proportion of time spent at home base equals the cumulative duration of staying at home base for periods shorter than 100 s, divided by the total cumulative duration of active locomotor behavior. As shown, most grooming proportions are located well above the diagonal of equal proportions. B: same explanation as for grooming. Here, individual rats are scattered around the diagonal of equal proportions.

visit to a place never lasted more than 100 s. As shown in Fig. 4A, during such periods of activity the proportion of grooming at a home base was higher than the proportion of time spent there ($P < 0.001$). In other words, the relationship between grooming incidence at home base and the time spent there is not a simple one, and the two are not linearly dependent.

Rearing on hindquarters

Rearing was performed in many places on the platform; nevertheless, home base incidences were the highest in 20 out of the 25 rats. A comparison of the average incidences, calculated with and without home base data, yielded a significant difference. Home base location is thus also marked by a high incidence of rearing.

While the cumulative time of staying at home base per fixed time interval increased in the course of the 1-h session, the incidences of rearing there decreased (Fig. 5). In other words, the shorter periods of staying at the home base were associated with frequent rearing. Nevertheless, because of the length of the session, long intervals of staying in place contributed a relatively large number of rearings to the total incidence of rearing at home base. To eliminate this bias, we compared the proportion of rearing at a home base to the proportion of time spent there during periods of active locomotion (periods in which the interval of staying at home base does not exceed 100 s — see Fig. 4B). As shown, unlike grooming, the proportion of rearing was *not* higher than the proportion of time spent in this place. We thus cannot exclude the possibility that the high incidence of rearing at home base merely reflects the long time of staying there.

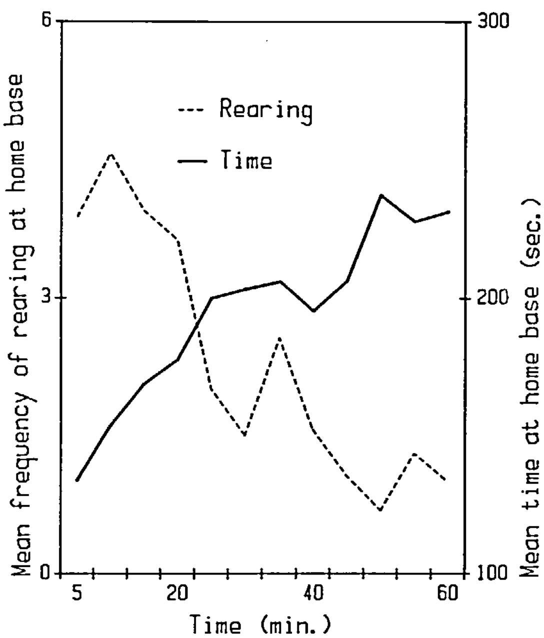

Fig. 5. Overall mean frequency of rearing at home base and overall mean time of staying at home base, per 5-min intervals, in the course of the 1-h observation period.

Number of visits

In the present study, a visit to a place is synonymous with stopping in that place. Although in each rat the incidence of visits to home base was particularly high, in some rats the number of visits to other places was equally as high and sometimes even higher. Nevertheless, a comparison of the two averages, calculated with and without home base incidences of visits, showed that the difference between averages is significant (Table I). Thus, the high number of visits to a home base can be used as another marker of home base location. Since the opportunity to visit the home base is clearly not increased by the time spent there, this feature may serve as a relatively independent measure of home base location (and vice-versa: the long intervals of staying at base — see Fig. 3 — exclude the possibility that cumulative time spent at base is a mere reflection of the number of visits to base).

We have thus shown that for the 25 rats observed in the present study there was at least one place — the home base — that stood out from all the other places in terms of the time spent there, the number of visits to it, the incidence of grooming, and to a lesser extent, the incidence of rearing in that place. In contrast, application of the two-average comparison to any other place on the platform does not yield a significant difference between the averages (Table I). We now proceed to examine the strength of this preference in individual rats.

III. Individual behavior

Rats with only one home base. Since the location of stopping was assessed in relation to a predefined system of places, it sometimes happened that a rat who settled on a boundary between two predefined places was recorded as switching between them. This artifact which was introduced by our recording procedure, had to be taken into account in the calculations that follow.

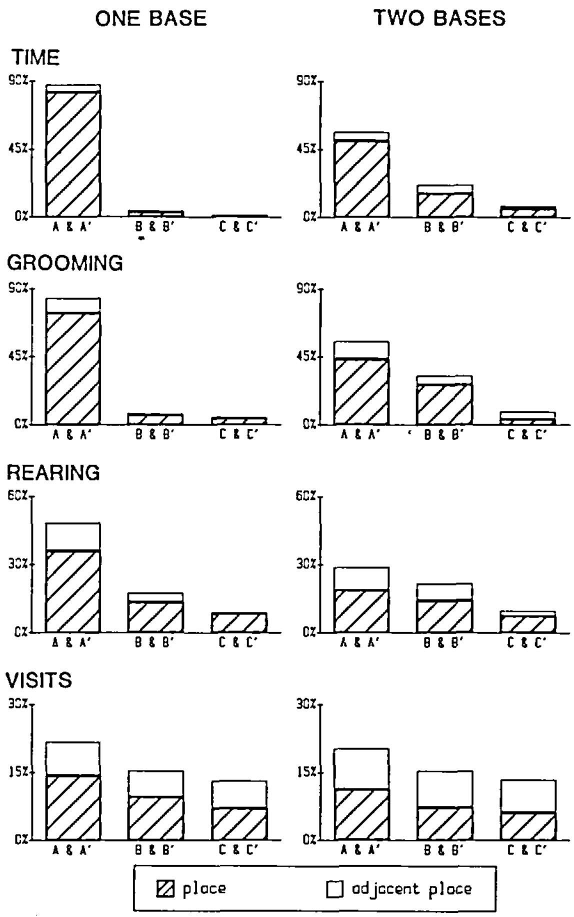

Fig. 6. Overall percentage of duration and incidences of various behaviors performed in 3 places on the platform: A represents in all graphs the place in which each of the rats separately, spent the largest cumulative amount of time; B represents the next non-adjacent place in which the rat spent the second longest amount of time, etc. A′, B′, C′ represent respectively adjacent places to A, B, and C (see text). The 4 horizontal rows present the data for the respective behaviors, and the 2 columns present the data for the one-base and the two-base groups. Results for each place are presented as the relative incidence of performance in all places where that behavior was performed across observation. As shown in the graphs of cumulative time and grooming, the difference between A and B is markedly larger in the one-base group than in the two-base group. The data of A′, B′, and C′ (empty bars) do not change the significance of the data presented for A, B, and C (diagonally hatched bars).

As shown in Fig. 3, 13 rats had only one home base: in 9, the home base happened to be confined to a single place (upper 3 rows of Fig. 3); in 3 rats, it was divided between 2 adjacent places (4th row from top, Fig. 3), and one rat settled on the junction between 3 adjacent places (bottom row, left rat).

The left column of Fig. 6 represents the time spent in the various places in this group of rats: A, B, and C represent, in decreasing order of magnitude, the cumulative duration of staying in place in the 3 non-adjacent places where each rat stayed for the longest time period. To represent properly the behavior of rats that settled on the boundary between two predefined places, place A′ designates the place adjacent to A, in which the rat spent the longest duration of time relative to all other places adjacent to A. B′ relates to B, and C′ to C in the same way.

As shown in the left column of Fig. 6, the time spent in A is longer than the time spent in the next non-adjacent place B ($P < 0.001$), regardless of whether A′ and B′ are included in the calculation.

Comparison of columns A and B of the one-base rats reveals that the difference is also significant for grooming ($P < 0.001$), rearing ($P = 0.006$), and the number of visits ($P = 0.007$). As shown in Fig. 6, inclusion of the data for A′ and B′ does not change these results.

The convergence of the highest values of the 4 examined variables to only one place that stands out from all the other places on the platform is readily apparent in the 4 examples presented in Fig. 7.

Rats with 2 bases. As shown in the middle portion of Fig. 3, 9 rats had two bases, located in spatially non-adjacent places (one of these bases was sometimes divided between two adjacent places). In addition, one rat had 3 non-adjacent places (Fig. 3, bottom row, middle rat), and in one rat it was difficult to assess the number of bases (Fig. 3, bottom row, right rat). These last two rats were included in the group of rats with two bases.

The strength of preference for the second place in this group of 11 rats was examined in relation to the various features of home base behavior. As shown in Fig. 6, the time spent by rats from this group in A is longer than the time spent in B

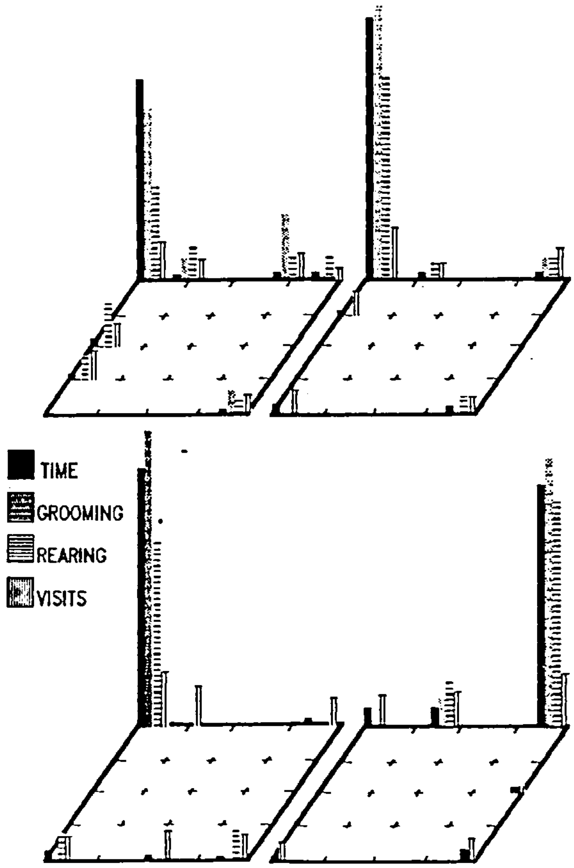

Fig. 7. The spatial distribution of 4 behaviors in 4 representative rats of the one base group. Rectangles represent the platform's surface. Marks on platform represent centers of predefined places (Fig. 1). Height of bars represents the relative proportion of time or relative frequency of respective behaviors. Data are presented for 5–7 places with highest values. As shown, in all 4 rats the high values converge to only one place.

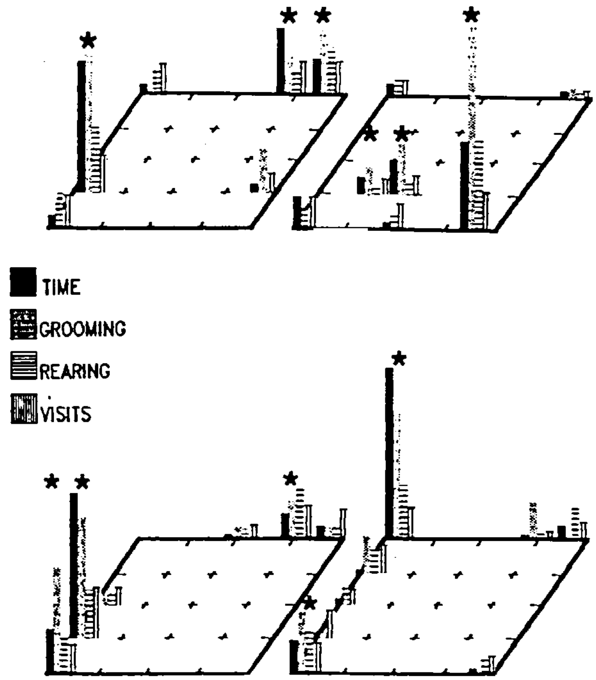

Fig. 8. The spatial distribution of 4 behaviors in 4 representative rats of the two-base group. For explanation of graphs see legend to Fig. 7. Asterisks above bars indicate base locations. Adjacent asterisks indicate a base established on the boundary between adjacent places.

($P < 0.001$). However, the difference between the first and the second place is smaller in the two-base group compared to the one-base group ($P < 0.001$). Furthermore, the difference between the second and third place is larger than in the one-base group ($P < 0.001$). It may be concluded that in the two-base group there is a second place which is lower than the first, but markedly higher than all the other places in terms of the time of staying in place. This place may thus be defined as a second base.

A comparison of the incidences of grooming and rearing in the first and second base of the two-base group (A and B in right column of Fig. 6) revealed no difference. In contrast, the difference established for the incidences of grooming and rearing in A and B of the one-base group was significant. We could not distinguish, however, between the one- and two-base groups, in regard to the number of visits paid to A and B.

The degree of convergence of behavior to the first and the second base, is illustrated in the 4 examples presented in Fig. 8.

IV. Other features of behavior in relation to home base

Crouching and pivoting around forelegs. During long periods of staying in place, rats typically crouch. Since long periods of staying in place define base location, crouching was found to be confined to base locations. Crouching is often interrupted by a peculiar type of turning in place, which consists of standing up, pivoting for 180° or more around the relatively stationary forelegs, and lying down again. In a few cases, this type of pivoting was observed without being preceded or followed by crouching. During pivoting around the forelegs, the hindlegs step more frequently than the forelegs. In all other places on the platform, rats typically pivot around the relatively stationary hindlegs, stepping sideways more frequently with the forelegs. Considering data of all rats, there were 216 incidents of pivoting around the forelegs, of which 80% were performed at the bases.

Comparison of progression on the way out and on the way in to base. Observation of video tapes revealed that progression away from home base was typically slower, and involved more stops than progression back to base. To establish this difference quantitatively, we located the furthest place where each rat stopped during each excursion away and back to base (the round trip between two successive visits to base), thus distinguishing between the way out and in. A comparison of the time spent on the way out and on the way in, revealed that the time spent on the way out was higher ($t = 5.510$; $P < 0.001$). A similar comparison of the number of stops performed by rats on the way out and on the way in revealed that their number on the way out was similarly higher ($t = 5.752$; $P < 0.001$). Home base location thus determines the mode of progression throughout the platform.

Choice of home base location. Rats tended to establish a home base along the edge of the platform, preferentially at a corner (Fig. 9). The use of 10 out of the 25 available places on the platform for a base (see Fig. 3), indicates that in this particular environment, base location is not determined exclusively by the physical features of the testing environment; in other words, rats did exercise a certain amount of individual preference in the choice of home base location.

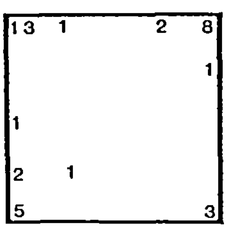

Fig. 9. Locations of bases on observation platform, in all 25 rats. Rectangle represents platform. Numeral placing indicates location of bases on platform. The numbers indicate the number of bases established in the particular place. (The total number of bases in this figure is 37 and represents 13 rats with a single base, 9 rats with 2 bases, and 2 rats with 3 bases. Adjacent bases are not shown in this illustration; see Fig. 3.)

DISCUSSION

Behavioral markers of base location

In a study of forced exploration in hooded laboratory rats in a complex environment[17], it was found that all rats ($n = 6$) established a home base, in which they spent large amounts of time (mean duration — 10 times longer than the next highest place); groomed more frequently than expected by the duration of staying there; performed longer bouts of crouching than in any other place; reared for longer intervals (mean duration of single rearings 1.5 times longer than elsewhere); stood for longer mean intervals; and maintained snout contact with substrate for significantly shorter intervals than in any other place. Mean duration of staying at base increased in the course of the testing period, but short visits to base (<20 s) occurred throughout. The author reports that despite his attempts, he could not establish any systematic organization of progression in the environment in relation to home base location.

Our results similarly show that staying in place, grooming, rearing, crouching, and long visits, all converge to a particular place. In addition, we show that rats may have more than one base, that the number of visits to the bases is higher than to any other place, that pivoting around forelegs is performed almost exclusively at base, and that home base location exerts a pervasive influence on the mode of progression throughout the environment. Geyer and colleagues[10–12], who tested rat locomotor behavior in a small chamber (12 x 24″), also noted that the outward part of the excursion of a rat from its 'home' corner 'is less direct and more interrupted by investigatory holepoking and rearing than the return part'.

It should be noted that although the frequencies of grooming, and to a lesser extent of rearing, can be used as dependable markers of home base location, some rats display little or no rearing or grooming in the course of the hour[13], but still establish a preferred place in terms of the other variables measured in this study. In addition, the return portion of a round trip made from a home base is often marked by a higher gait or even by running (Eilam and Golani, unpublished observations)*. In summary, the most durable features of home base related behavior seem to be the large number of visits, the time spent there, and the mode of progression in relation to home base location.

The testing environment

In a highly structured environment, the shape of behavior may simply reflect the physical and perceptual features of this environment[18]; these features may then be used to explain away the properties of behavior. One method traditionally used by ethologists, is to observe animals in impoverished environments. If a behavior is nevertheless performed in such a 'vacuous' environment, its features are more likely to have a stronger endogenous component[16]. It is, for instance, easy to devise an environment with one appropriate hiding place, where all rats will establish a home base. In such a case, it would be tempting to explain away the rat's behavior by attributing to it the functional significance of, for example, hiding. But if rats establish home bases on a relatively homogeneous platform, each in a different individually chosen place, and if some of these bases are located away from corners and edges, then the home base is more likely to have a component intrinsic to the behavior, rather than be mostly a reflection of environmental constraints. From this point of view, the fact that some bases were established away from nearby identifying stimuli (Fig. 9) shows that the tendency to establish a base is so strong, that it may even be established in partial 'vacuum'.

In searching for a testing environment that would reveal intrinsic constraints, we realized that if the environment is too impoverished, it does not elicit exploration. In other words, to elicit locomotor behavior that consists of a regular alternation between progression and stopping, the environment must be partly structured. Our testing environment is therefore a compromise between two conflicting demands: it is homogeneous in terms of proximal stimuli, and structured in terms of distal stimuli. In a way, it constitutes a combination between the properties of the traditional open field in that it exerts minimal constraints on the rat's path of movement, and between the properties of the elevated maze, in that it allows the rat free visual access to the more distal environment.

To examine the effects of constraints which were nevertheless imposed — corners, arena size, artificial lights, and forced introduction to the environment — rats were also observed in 3 additional environments which differed in size and shape (see Methods). Some rats were placed in a large yard with their home cage opened. In all environments, and during both forced and free exploration, all rats established 1–2 bases typically along the edge. In free exploration in the large yard, one of the bases was always located in the rats's home cage. In the large yard, rats typically established a second base, and returned to it repeatedly without visiting the main base for some time. Finally, when juvenile rats (age 16–44 days) were repeatedly introduced, in the course of their ontogeny, into the same large (3 × 3 m) complex environment, during the dark part of their cycle, home bases proliferated from 1 to as many as 6 places. Proliferation took place both day by day and in the course of daily sessions (Tchernichovski and Golani, unpublished results). The establishment of such bases might be a way used by rats in the wild to expand the portion of the environment through which they move, without having to return all the way to the main base.

The home base is an intrinsic component of organized locomotor behavior

It has been suggested[1] that whether locomotor behavior in a novel environment should be described in terms of escape or exploration, depends on the presence of a familiar place (e.g. the home cage). Our results show that if a familiar place is

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* It is related that this last feature of homing behavior was known even to a Russian Tzar, who, upon having to travel from St. Petersburg to Moscow, always ordered the horses from Moscow, and vice versa.

not supplied, it is established by the rat. Therefore, the distinction between free and forced locomotor behavior (which is determined by the availability of a familiar place), is not all that crucial from the point of view of the present study. Whether the rat engages in exploration, or escape, or a mixture of both, it nevertheless establishes a home base in the course of the first few minutes of observation (Figs. 2 and 3).

Another hypothesis that could be made is that since the rats were tested in the daylight part of their cycle, they were merely preparing to go to sleep — exploring briefly, grooming, and then turning in a nest-shaping fashion (foreleg pivot in the present study), before settling down[3,13]. This hypothesis is ruled out because: (a) base features during *free* exploration in the large yard (see Methods) appeared indistinguishable from base features during forced exploration, and (b) under amphetamine (0.5–5 mg/kg), a drug which induces hyperactivity and eliminates crouching and settling down, the same rats displayed, in the same environment, all the other features of base behavior[7].

Finally, the home base phenomenon is not an artifact of post-weaning handling[6,15], having been reported in unhandled rats[17]. Neither is it restricted to laboratory conditions[4,14], or to rodent behavior[18].

Home base behavior thus appears to be an intrinsic component of organized locomotion in a novel environment. The location of base may be conveniently identified by the observer, through use of the behavioral markers documented in the present study. Once these locations are established, they can be used as reference points in the measurement of other aspects of behavior away from the base. To an extent, such reference points have already been used in water navigation studies[20], brain damage studies[21], and studies of rat behavior under the influence of drugs[7,9,12].

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