

OPEN-FIELD EXPLORATION AND EMOTIONAL REACTIVITY IN MICE

Generós Ortet y Manuel Ignacio Ibáñez

University of Castelló

Ambulation (exploratory behaviour) and defecation (emotional reactivity) in the Garcia-Sevilla's (1984) low-frightening open field have been proposed as analogous in rats to extraversion and neuroticism personality dimensions. The present study was designed to study these behaviours with the modified version of the open field test in mice. However, ambulation was considered as a possible parallel of human sensation-seeking. According to the previous experiments, no significant negative correlations were found between ambulation and defecation, as usually found between sensation-seeking and anxiety/neuroticism in man. Moreover, a significant decrease of ambulation was also found between the first and fourth day of exposure to the test, as the repeated exposure to the same environment seem to lower interest in human high-sensation seekers. Finally, the animals' weight was independent of ambulation in both mouse strains used, and was independent of defecation for Swiss Albino mice.

La exploración y la reactividad emocional del ratón en el campo abierto. La deambulaci3n (conducta exploratoria) y la defecaci3n (reactividad emocional) en el campo abierto poco amenazador de Garcia-Sevilla (1984) se han propuesto como an3logos en ratas de las dimensiones de personalidad extraversi3n y neuroticismo. Este estudio se dise1n3 para estudiar estas conductas en esta versi3n modificada del campo abierto con ratones. Sin embargo, la deambulaci3n se consider3 como un posible paralelo de la b3squeda de sensaciones humana. Al igual que en experimentos previos, encontramos correlaciones negativas no significativas entre deambulaci3n y defecaci3n, como generalmente ocurre entre b3squeda de sensaciones y ansiedad/ neuroticismo en humanos. Adem3s se encontr3 un decremento significativo de la deambulaci3n entre el primer y cuarto d3a de exposici3n al test, del mismo modo que la exposici3n repetida al mismo ambiente parece disminuir su inter3s para los altos buscadores de sensaciones humanas. Finalmente, el peso de los animales fue independiente de la deambulaci3n en ambas cepas de ratones, as3 como de la defecaci3n en los ratones Swiss Albino.

Nowadays there is an important amount of empirical evidence related to the contribution of genetic factors to basic personality

traits. The behaviour-genetic studies represent two traditions (Goldsmith, 1989): human family, twin, and adoption studies of a variety of traits, usually assessed via questionnaires (e.g. Plomin and Daniels, 1987; Plomin, Chipuer and Loehlin, 1990; Eysenck, 1990; Zuckerman, 1991; Loehlin and Rowe, 1992; Goldsmith, Losoya, Bradshaw and Campos, 1994; Pedersen, 1994); and la-

Correspondencia: Gener3s Ortet
Department of Psychology
Jaume I University of Castell3
12080 Castell3 (Spain)
E-mail: ortet@psb.uji.es

boratory research of animal models of personality (e.g. Chamove, Eysenck and Harlow, 1972; Garcia-Sevilla, 1984; Mather and Anderson, 1993; Gold and Maple, 1994; Draper, 1995; Forkman, Furuhaug and Jensen, 1995; Dellu, Piazza, Mayo, Le Moal and Simon, 1996). The first line of research has had an important development and there are already studies related to the identification of specific genetic locus that contributes to personality traits (Benjamin, Li, Patterson, Greenberg, Murphy and Hamer, 1996; Ebstein et al., 1996). The second line of research, animal models of human personality traits or dimensions has had a less impressive progress, especially among animal psychologists (see Eysenck and Eysenck, 1985; Zuckerman, 1991 for a review). These researchers consider that the main personality traits may be understood as genetically based behaviour patterns developed in terms of Darwinian evolutionary principles and based on common physiological structures and hormonal activity.

García-Sevilla (1984) and Garau, Martí, Pérez-Mourelo and Garcia-Sevilla (1991) describe a full series of studies related to parallels of Eysenck's extraversion and neuroticism in rats. In these investigations, ambulation (more related to exploratory than activity measures) and defecation (emotional reactivity) in a low-frightening open field were proposed as measures of extraversion and neuroticism respectively. This open field was created modifying the one standardised by Broadhurst (1957) with the elimination of the 78 dB white noise. Under these conditions, ambulation and defecation measures were not correlated to each other or showed a low negative correlation (Garcia-Sevilla, 1984).

However, it has been argued that the core of extraversion is sociability (Zuckerman, 1991) and this dimension, together with agreeableness, appears as very relevant to interpersonal behaviour (McCrae and Costa, 1989). So, it seems that the social behaviour

of animals in controlled colony environments may be a better parallel of human extraversion; and ambulation in the open field may be a more appropriate measure of sensation seeking, especially as an analogous to the adventure seeking type in the human (Zuckerman, 1994). Accordingly, Garau (1984), using factor analyses of rodent behaviour in the low-frightening open field and other tests (e.g., Y-maze, dark-light, hole-board), found that the ambulation appeared to be associated with the extraversion trait stimulation seeking (sensation seeking).

Dellu, Mayo, Piazza, Le Moal and Simon (1993) and Dellu, Piazza, Mayo, Le Moal and Simon (1996) have proposed that individual differences of locomotor reactivity to novelty in rats (assessed by a test that consists of a circular corridor) as a possible parallel of sensation seeking. They found that the high responders (HR) rodents, opposed to low responders (LR), are highly reactive in different behavioural tests that measure the free-choice response to novel environments (i.e., exploration in a Y-maze, exploration in a 16-arm radial maze, and a dark-light emergence test). These authors consider that the response to novelty is crucial to the definition of sensation seeking, and suggest an animal model with characteristics that are analogous to some of the factors found in this human trait. Moreover, HR rats have been found to be predisposed to drug-taking, like sensation seeking is related to drug use (Zuckerman, 1994), and rapidly develop intravenous self-administration of amphetamine while the LR do not (Piazza, Demière, Le Moal, and Simon, 1989). However, Gong, Neill and Justice (1996) found that HR rats did not developed place-preference conditioning with cocaine more readily than LR rats. Dellu et al. (1993; 1996) have pointed out that there are also neurochemical and neuroendocrinological differences between HR and LR rats related to dopaminergic activity in the nu-

cleus accumbens and the level of corticosteroids. Accordingly, HR rats (and high sensation seekers as defended by Zuckerman, 1994) may seek novelty situations for the reinforcing properties of the neurochemical and neuroendocrinological activity enhanced by intense, varied, novel and complex sensations, and risk-taking activities.

The main aim of the present research was to study exploration and emotional reactivity with the Garcia-Sevilla's (1984) low-frightening open field in mice. For this purpose, ambulation (exploration) in the open field was considered as an indication of the adventure seeking type of sensation seeking, and defecation (emotional reactivity) was considered as an indication of neuroticism/anxiety. According to Zuckerman's (1994) sensation seeking concept, it was predicted that correlations between ambulation and defecation would be low negative in the two strains of mice used, as it is usually found between sensation seeking and neuroticism/anxiety in humans. Because repeated exposure to the same open field environment decreases its novelty, conversely it was predicted that ambulation would decrease across the four days of testing. In addition, it was predicted that ambulation and defecation in the open field would be independent of other biological measures, such as animal's weight.

Method

Subjects

Twenty four male mice from outbred (12 Swiss Albino) and inbred (12 C57BL/6) strains obtained from Interfauna Ibérica, S.A., Barcelona, Spain (Sprague Dawley Co.) served as subjects. Animals were 4 weeks old at the start of testing and were housed, 4 per cage, on arrival with food and water freely available. All mice were maintained in a room temperature of 22°C with

controlled humidity, where 12 hr light-dark schedule with light off 08:00-20:00 was in effect. Experimentation took place during the dark phase of the cycle.

Apparatus and behavioural testing

Low-frightening open field. The apparatus was a square transparent plastic cage (50 x 50 x 40 cm high) divided into 25 equal squares. A lamp with three fluorescent 36W bulbs, hanging 1 m above the centre of the open field, provided the illumination. One week after arrival, animals were placed at the centre of the open field and observed during 5 min. Testing was repeated at the same time on four subsequent days. After testing, subjects were weighed and returned to the home cage. The number of lines crossed by the hind legs were recorded as a measure of ambulation (exploratory behaviour), and the number of boli deposited were recorded as a measure of defecation (emotional reactivity).

Statistics

The normality of the 2 strain distribution on the behavioural and weight measures was verified using Kolmogorov-Smirnov test. The consistency of behavioural responses was analysed by using Cronbach's coefficient alpha. Student's *t*-test was used to compare between strains. An analysis of variance (ANOVA) for repeated measures was used for comparisons among the behavioural measures during the four days. All measures were correlated using Pearson's correlation coefficient. The accepted level of significance was $P < 0.05$ for all statistical test.

Results

The normality of the two samples for the three variables was verified: Swiss Albino

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(ambulation, $Z = 0.51, p = 0.9$; defecation, $Z = 0.60, p = 0.9$; weight, $Z = 0.38, p = 0.9$); C57BL/6 (ambulation, $Z = 0.58, p = 0.9$; defecation, $Z = 0.57, p = 0.9$; weight, $Z = 0.54, p = 0.9$). Table 1 shows, for the two mouse strains, means and standard errors of mean of ambulation, defecation and weight along with the mean comparisons and reliability coefficients. It shows that significant differences between strains were only found for weight. Alpha reliability coefficients were high for both behavioural measures for Swiss Albino strain, however it was very low for defecation by C57BL/6 group, being ambulation the most consistent measure.

	Swiss Albino	α	C57BL/6	α
Ambulation	608.6 ± 34.5	0.79	599.5 ± 31.4	0.89
Defecation	18.0 ± 2.5	0.66	15.1 ± 1.3	0.16
Weight	28.5 ± 0.5		19.80 ± 0.3***	

*** $P < 0.001$ versus Swiss Albino (Student's *t*-test).

Table 2 presents the correlation coefficients between the behavioural and weight measures. Although most correlations were high, only the coefficient between defecation and weight for C57BL/6 strain was significant.

Figure 1 shows that daily repeated exposure to the low-frightening open field decreased the number of crossings (ambulation). ANOVA showed that, for both strains, the highest ambulation was observed during the first day, while the lowest was scored on the fourth day [Swiss Albino: $F(3,33) = 3.50, P < 0.05$; C57BL/6: $F(3,33) = 13.79, P < 0.001$].

	1	2	3
1. Ambulation	-	-0.30	-0.55
2. Defecation	-0.35	-	0.67*
3. Weight	0.35	0.10	-

* $P < 0.05$

Figure 2 shows that repeated exposure had no effect on defecation for Swiss Albino mice [$F(3,33) = 2.36, P = NS$], but the ANOVA showed significant differences for C57BL/6 mice [$F(3,33) = 4.12, P < 0.05$]. Thus, for C57BL/6 the highest score was observed during day 2 and the lowest during day 1.

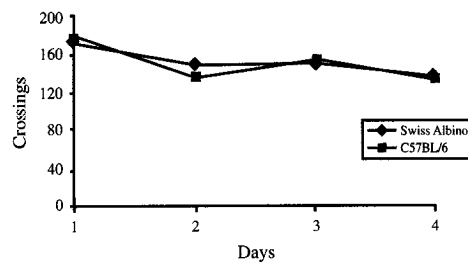


Figure 1. Ambulation (exploration) in the low-frightening open field.

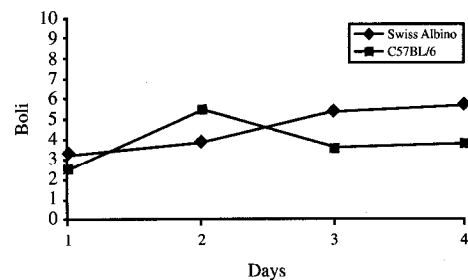


Figure 2. Defecation (emotional reactivity) in the low-frightening open field.

Discussion

Results showed that two behavioural measures, ambulation and defecation, in the low-frightening open field provided an acceptable level of internal consistency for Swiss Albino and C57BL/6 mouse strains. The only exception was defecation for the second group. The obtained reliability coefficients are similar to those found in previous studies with rats (cf. Garau, 1984; Goma and Tobeña, 1978). There were no significant differences between the behavioural measures in the two strains of mice. However, Swiss Albino rodents were clearly bigger than C57BL/6.

Results were consistent with those found by Garcia-Sevilla (1984) and Garau et al. (1991) with rats. That is, correlations between ambulation (exploration) and defecation (emotional reactivity) in the low-frightening open field were negative but not significant for both mouse strains. In relation to our hypothesis, these data can be better interpreted in the line of the low negative correlations usually found between sensation seeking and anxiety/neuroticism dimensions in humans (Zuckerman, 1994). Ambulation measure is considered as a possible analogous to sensation seeking (especially the adventure seeking type) in humans. In keeping with previous studies with rats (e.g. Garcia-Sevilla, 1984), ambulation and defecation were independent of other biological measures, such as the animal's body weight in Swiss Albino mice. Also, ambulation was not significantly correlated to weight for C57BL/6. However, a positive significant correlation between defecation and weight was found for C57BL/6 strain which would indicate an unpredicted direct relationship between defecation and body weight.

According to our expectations, a significant decrease in ambulation between the

first and fourth day of exposure to the low-frightening open field was also found in mice (cf. Garau, 1984; Garau et al., 1991). As it was hypothesised, repeated exposure to the same environment decreased its novelty, as a result exploratory behaviour (ambulation) also decreased (cf. Dellu et al., 1993). Results have characteristics that resemble the relevance of novelty in human sensation seeking. Furthermore, the current study found no significant differences in defecation among the four days of exposure for Swiss Albino mice. This may be due to the low-frightening characteristics of the test. This open field is designed to enhance low levels of fear, so the repeated exposure would not influence the habituation of the animal's emotional reactivity to the experimental situation. Nonetheless, an unexpected pattern with significant differences among sessions was found for this measure by C57BL/6 strain which is difficult to interpret.

Overall, results found in this study on the low-frightening open field test supported most of our predictions. These were: 1) no significant negative correlations between ambulation and defecation were found, 2) a significant decrease of ambulation between the first and fourth day of exposure was observed, and 3) an independence between ambulation and defecation of body weight was obtained, especially with the Swiss Albino strain.

More experiments are needed to take exploratory behaviour (ambulation) and emotional reactivity (defecation) of mice in Garcia-Sevilla's (1984) low-frightening open field as analogous measures to sensation-seeking and anxiety traits in humans. Other studies with bigger and varied samples of animals are required. Moreover, it seems necessary to compare the low-frightening open field test with other exploratory (e.g., Dellu et al.'s, 1993, novelty-induced locomotor activity or Lister's, 1987, hole-board)

and emotional reactivity (e.g., Lister's, 1987, plus-maze) behavioural tests in mice. And last but not least, studies about the hereditary, and the neurochemical and neuroendocrinological characteristics of exploration and emotional reactivity in the low-frightening open field test are required in relation to biological correlates of sensation seeking (e.g., dopaminergic activity) and anxiety (e.g., serotonergic activity) proposed in humans.

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