Behavioural Brain Research 284 (2015) 112–117

Contents lists available at ScienceDirect

Behavioural Brain Research

journal homepage: www.elsevier.com/locate/bbr

Research report

Social exclusion intensifies anxiety-like behavior in adolescent rats

Hyunchan Lee, Jihyun Noh*

Department of Science Education, College of Education, Dankook University, 152 Jukjeon-ro, Suji-gu, Yongin-si, Gyeonggi-do 448-701, Republic of Korea

HIGHLIGHTS

- Freely moving rats showed social contagion from stressed conspecific rat.
- Anxiety-like behavior in unequally excluded rats significantly increased.
- Emotional distress intensifies in positions of social exclusion.

ARTICLE INFO

Article history:
Received 1 October 2014
Received in revised form 28 January 2015
Accepted 3 February 2015
Available online 11 February 2015

Keywords:
Adolescence
Anxiety
Empathy
Inequality
Restraint stress
Social exclusion

ABSTRACT

Social connection reduces the physiological reactivity to stressors, while social exclusion causes emotional distress. Stressful experiences in rats result in the facilitation of aversive memory and induction of anxiety. To determine the effect of social interaction, such as social connection, social exclusion and equality or inequality, on emotional change in adolescent distressed rats, the emotional alteration induced by restraint stress in individual rats following exposure to various social interaction circumstances was examined. Rats were assigned to one of the following groups: all freely moving rats, all rats restrained, rats restrained in the presence of freely moving rats and freely moving rats with a restrained rat. No significant difference in fear-memory and sucrose consumption between all groups was found. Change in body weight significantly increased in freely moving rats with a restrained rat, suggesting that those rats seems to share the stressful experience of the restrained rat. Interestingly, examination of the anxiety-like behavior revealed only rats restrained in the presence of freely moving rats to have a significant increase, suggesting that emotional distress intensifies in positions of social exclusion. These results demonstrate that unequally excluded social interaction circumstances could cause the amplification of distressed status and anxiety-related emotional alteration.

1. Introduction

Human beings rely on social life for their health and well-being, which means social bonding is the most pivotal factor for human beings [1]. It is generally understood that those who live in groups are likely to have greater survival and reproductivity, while those who are excluded from the group may be less likely to survive and can exhibit several alarming disorders [2]. Being accepted into a social group is therefore a crucial goal of humans, while being excluded can be highly distressing [3].

Pro-social behavior and empathy are important components of the human emotional experience and social interaction in groups. A sense of fairness or aversion to disadvantageous inequity appears to be critical for the development of successful cooperation in larger groups of individuals. Inequity aversion is defined as partners resisting inequitable outcomes. In humans, it seems to be based on the simultaneous evaluation of costs and gains compared with those of a partner. Some recent reports have demonstrated that non-human animals such as capuchin monkeys, chimpanzees and dogs respond negatively to unequal reward and have sensitivity toward unequal reward distribution [4–6]. Rodents behave pro-socially in response to the distress of conspecifics and are capable of displaying empathically motivated helping behavior [7]. Sense of fairness in rodents has been suggested; the stress in mice restrained with restrained mates is decreased due to social equality, whereas that in mice restrained in the presence of freely moving mates is elevated due to social inequity [8].

Social interaction and communication are essential not only for cooperation within a group, but also for protection from environmental threats; this is one of the most beneficial aspects of establishing a society. Social relationships and interpersonal behaviors exert regulatory influences on physiological, behavioral,

* Corresponding author. Tel.: +82 31 8005 3842; fax: +82 31 8021 7231.
E-mail addresses: jihyun2@dankook.ac.kr, jihyun2@gmail.com (J. Noh).

http://dx.doi.org/10.1016/j.bbr.2015.02.006
0166-4328/

and dispositional responses to emotionally charged situations [9]. Social interactions can either be a source of stress or provide a buffer against stress depending on the circumstances. Social transmission of information or social contagion from fearful or stressed conspecific animals exacerbates the fear or stress response, whereas social supportive experience from non-fearful animals lessens the stress responses, a phenomenon referred to as 'social buffering' [10–12].

The development of an animal is influenced by environmental factors, including the amount and quality of contact with other animals acting as social contagion or social buffering, as well as other external environmental factor such as social equality state. To determine the effect of equal or unequal social environment interactions on emotional change in adolescent distressed rats herein, we examined the emotional alteration induced by restraint stress in an individual rat following exposure to various social interaction circumstances. Female adolescent rats were assigned to one of the following groups: all freely moving rats, all rats restrained, rats restrained in the presence of freely moving rats and freely moving rats with a restrained rat. After exposure to restraint stress, the fear memory, anxiety and stress-related behaviors were examined.

2. Materials and methods

2.1. Animals and housing conditions

All experiments were conducted in accordance with the Dankook University Ethics Committee's guidelines for the care and use of laboratory animals. Female Sprague–Dawley rats were obtained from Samtako Bio Korea (Osan, Korea). They were housed three animals per cage during the acclimation period in Plexiglas cages (46 × 23 × 20 cm) with wood bedding. All rats were housed at a constant temperature (23 ± 1 °C) and humidity (45 ± 5%) in a sound attenuating isolated room during care and experimentation. Illumination was maintained in a 12:12-h regular light–dark cycle (light on 09:00–21:00), and the rats were provided with free access to food and water.

Table 1
Description of the experimental groups.

Abbreviation	Description
Control	All freely moving rats in the experimental chamber
Empathy	Each cage mate restrained individually in the experimental chamber
Exclusion	Rat restrained with two freely moving rats
Observer	Freely moving rats with a restrained rat

2.2. Restraint stress procedure

All rats were conditioned between PD (Postnatal Day) 25 and 31 (50–110 g) and their cages were divided into four groups (Table 1; Fig. 1). Each group was exposed to the experimental chamber at the same time and then each rat was returned to their home-cage with cage mates. For the restraint stress experiment, rats were introduced into the experimental chamber, a noble Plexiglas cage (46 × 23 × 20 cm). The restraint stress procedure was carried out in a sound attenuating isolated room, and the restraint holder was placed in the experimental chamber. Rats which were inserted into the holder received restraint stress for 2 h at a time. This procedure was repeated for 7 consecutive days.

2.3. Light/dark box test

Rats were transferred to the testing room 30 min before they were introduced into the light/dark box (40 × 20 × 31 cm) for acclimation. Rats were transferred through the front door (8 × 8 cm) and placed in the dark compartment (approximately 1 Lx). The middle door between the dark compartment and the light compartment (110–150 Lx) was opened 3 s after the front door was closed. To reduce the noise from outside, the light compartment was covered with a transparent acrylic ceiling. The rats were allowed to explore the box for 15 min, during which their behavioral activities were recorded with a camcorder (HMX-H304BD, Samsung Electronics Co., Ltd., Suwon, Korea) through a window in the transparent ceiling of the light compartment.

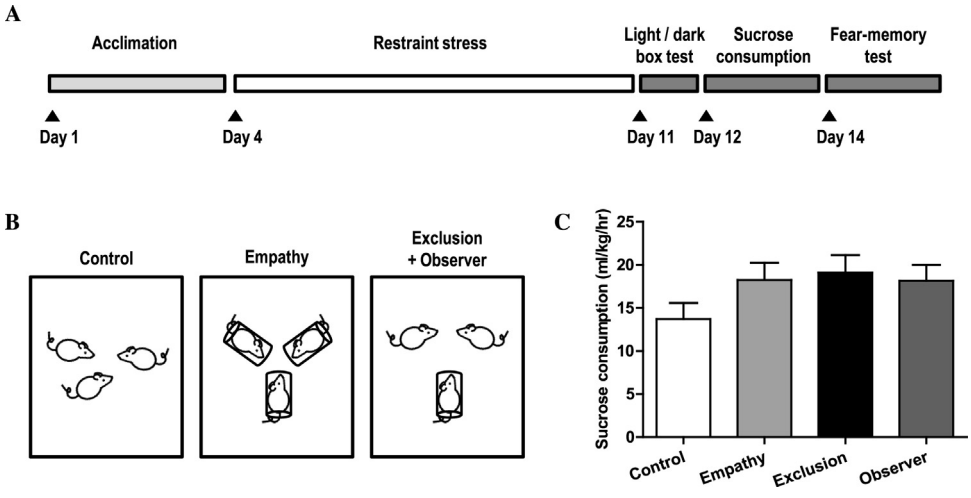

Fig. 1. Experimental procedures and description of assigned experimental groups. (A) Schematic time line showing the different stages of each experiment. Rats in the assigned groups were exposed to restraint stress paradigm, respectively, for 7 days. After restraint stress was conditioned, rats in individual groups were tested for anxiety, sucrose consumption and fear memory induced by the different social environmental conditions during the restraint stress paradigm. (B) Rats were assigned to one of the following groups: control group containing all freely moving rats, empathy group containing each cage mate restrained individually, exclusion group where rats were restrained in the presence of freely moving rats and observer group where freely moving rats were with a restrained rat. (C) Sucrose consumption was expressed as the volume of total sucrose intake divided by the weight of rats, and the total time spent during the test period. There was no statistically significant difference in sucrose consumption between groups as determined by one-way ANOVA ($F(3, 32) = 1.46$, $P > 0.05$; Control, 13.72 ± 1.88, $n = 9$; Empathy, 18.27 ± 1.99, $n = 9$; Exclusion, 19.12 ± 2.05, $n = 6$; Observer, 18.16 ± 1.84, $n = 12$). Data are expressed as mean ± SEM.