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ORIGINAL PAPER

Rats demonstrate helping behavior toward a soaked conspecific

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Abstract Helping behavior is a prosocial behavior whereby an individual helps another irrespective of disadvantages to him or herself. In the present study, we examined whether rats would help distressed, conspecific rats that had been soaked with water. In Experiment 1, rats quickly learned to liberate a soaked cagemate from the water area by opening the door to allow the trapped rat into a safe area. Additional tests showed that the presentation of a distressed cagemate was necessary to induce rapid door-opening behavior. In addition, it was shown that rats dislike soaking and that rats that had previously experienced a soaking were quicker to learn how to help a cagemate than those that had never been soaked. In Experiment 2, the results indicated that rats did not open the door to a cagemate that was not distressed. In Experiment 3, we tested behavior when rats were forced to choose between opening the door to help a distressed cagemate and opening a different door to obtain a food reward. Irrespective of how they learned to open the door, in most test trials, rats chose to help the cagemate before obtaining a food reward, suggesting that the relative value of helping others is greater than the value of a food reward. These results suggest that rats can behave prosocially and that helper rats may be motivated by empathy-like feelings toward their distressed cagemate.

Keywords Prosocial behavior · Helping behavior · Empathy · Rats

Introduction

Sensitivity to the emotions of conspecifics, through empathy or emotional contagion, is important to facilitate smooth communication with others and is necessary for an adaptive social life. As opposed to antisocial behavior, prosocial behavior is socially desirable behavior that benefits other individuals (Eisenberg and Miller 1987). In humans, even 1-year-old children show prosocial behavior toward others when they recognize sadness in other people (Bischof-Khöler 1991; Warneken and Tomasello 2006, 2009; Zahn-Waxler et al. 1992). Although this kind of ability has previously been thought to be specific to humans (Fehr and Fischbacher 2003) or at least to non-human primates (Clay and de Waal 2013; de Waal 2008; Preston and de Waal 2002), it was recently reported that rodents can show emotional contagion (Atsak et al. 2011; Chen et al. 2009; Langford et al. 2006), can demonstrate the effects of social cues on learning (Akyazi and Eraslan 2014; Knapska et al. 2010), and can display signs of cooperation (Rutte and Taborsky 2007; Viana et al. 2010).

Helping behavior, one of the prosocial behaviors, refers to behavior that improves the status quo of another individual. The existence of helping behavior in non-human primates has recently been reported (Melis et al. 2011; Warneken and Tomasello 2006; Yamamoto et al. 2012). Some classic studies had reported on rats helping other individuals (Church 1959; Rice and Gainer 1962); however, since understanding the distinction between

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self and others is thought to be essential for altruistic behaviors such as prosocial and helping behavior (Decety 2011; Fehr and Fischbacher 2003), the existence of such social abilities has been considered unlikely in non-primate animals.

Bartal et al. (2011) recently reported that rats can exhibit helping behavior. They reported that rats opened a door to free their cagemate from being constrained in an acrylic tube. The rats did not open the door when the tube was empty or when the cagemate was replaced by an object. These results suggest that rats exhibit prosocial behavior to eliminate distress in another even without concrete reward.

In the present study, we examined helping behavior in rats using another distress situation. We used a pool of water to create distress. Rats avoid bathing in water in the water maze task and escaping from water is thought to be the primary motivator (Morris 1981). There were three experiments in the present study. In Experiments 1 and 2, we examined helping behavior in rats. We also examined the influence of prior experience on helping behavior. We predicted that rats with prior experience of an aversive situation would learn to help a cagemate faster than those that had not been previously exposed. In Experiment 3, we examined the value of helping through a choice test in which one choice resulted in helping and the other resulted in a food reward.

Experiment 1

In Experiment 1, we investigated whether rats help their cagemates in a distress situation. We created the distress situation by soaking a rat in water. In addition, we carried out several control tests to confirm the importance of the existence of the distressed other individual for occurrence of the helping behavior. To confirm the experimental operation, the rats were tested for preferences regarding water. Finally, we examined the effects of prior experience of exposure to the distress situation. If the helping behavior is motivated by empathy, such a prior experience should lead to the rat engaging in the helping behavior more quickly.

Methods

Subjects

The subjects were ten female and ten male rats, 10-week-old Sprague–Dawley rats (Japan SLC, Hamamatsu), weighing an average of 214 g (female) and 362 g (male) at the beginning of the experiment. All rats were from different litters. They were housed in pairs in a plastic cage (260 × 420 × 180 mm) with wood chips on a 16-/8-h light/dark cycle (lights were on from 8:00 to 24:00) with controlled temperature (23 °C) and humidity (60 %). The rats were randomly paired with members of the same sex; there were five female and five male pairs. We did not observe any fighting behavior among the pairs. All rats were allowed free access to standard laboratory chow (Oriental Yeast, Japan) and water during all experiments. All experiments in this study were approved by the Animal Experimentation Committee of Kwansei Gakuin University (2012-04, 2013-01, 2014-19).

Apparatus

The experiments were carried out in an experimental box made of black polyvinyl chloride boards. The box was set up in an experimental room in which white noise was always played to mask external sounds. In the middle of the box, there was a transparent partition that divided the inside of the box into two areas (Fig. 1a). In one of the two areas, the floor was raised by 50 mm (ground area), and in the other, a pool of water 45 mm deep was created (pool area). The partition had a hole 65 mm in diameter through which the rats could pass between the two areas. In front of the hole, a transparent circular door 80 mm in diameter was held in place with a fastener (Fig. 1a). The door had a

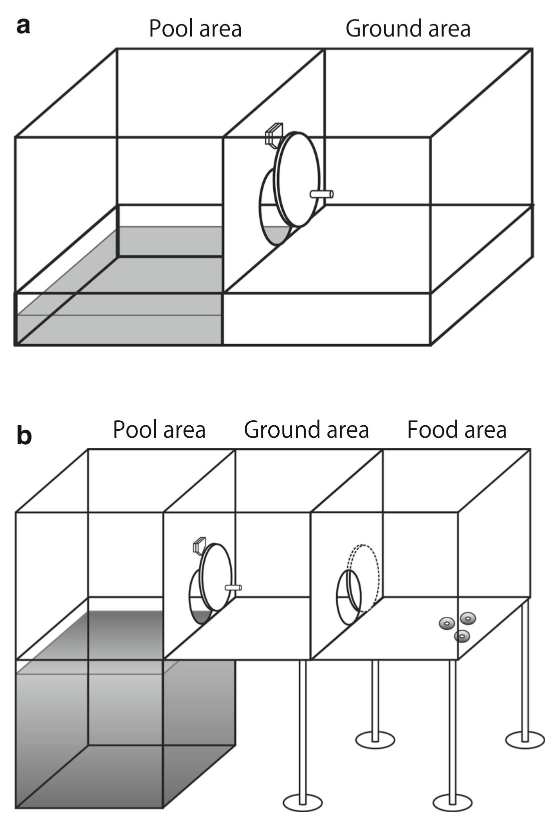

Fig. 1 Experimental boxes. **a** The box used in Experiment 1 **b** The box used in Experiments 2 and 3. In Experiment 2, the ground and food areas were used. There was water in the pool area

handle 30 mm from the center. The rat could push or pull the handle or directly move the door to roll the door open.

Procedures

After all rats were received from the breeding company, they were housed in pairs for 14 days to acclimate before starting the experimental sessions. On alternate days during the 14 days, the rats were handled for 5 min per day by a female experimenter to habituate them to human hands. After that, one of each pair of rats was randomly assigned as a helper and the other was assigned to be a soaked rat. There were four phases in Experiment 1: door-opening sessions, control tests, preference test, and role-reversal sessions.

Door-opening sessions (12 days)

In the first experimental sessions, the soaked rat was soaked in water in the pool area of the experimental box, and the helper rat was placed in the ground area. The helper rat in the ground area could open the door and liberate the soaked cagemate. We counted the moment when the helper rat was placed in the ground area as the beginning of the session and measured the time until the helper rat opened the door. Each experimental session was carried out for 300 s. One session was carried out per day for each pair, with each pair experiencing a total of 12 sessions.

Control tests (3 days)

After the door-opening sessions, we conducted three control tests on the helper rats that opened the door: pool, empty, and object tests. In the pool test, all conditions were the same as in the door-opening sessions except that there was no cagemate in the pool area. In the empty test, there was neither a cagemate nor water in the pool area. In the object test, there was a stuffed toy rat in the empty pool area. Only one test (pool, empty, or object) was carried out per day. All rats were tested with the same order (pool → empty → object).

Preference test (2 days)

After the three control tests, we examined the rats' preferences regarding water by making them explore the experimental box without the door. In this test, there was water with no cagemate in the pool area. We put the rat into the ground (or pool) area and measured the time spent in each area. All rats were tested two times (once in the ground area and the other in the pool area), and the order was counter-balanced. Each test was carried out for 300 s, and each rat was tested once per day for 2 days.

Role-reversal sessions (6 days)

Finally, we conducted role-reversal sessions. In these sessions, the rats' roles from the door-opening sessions were reversed, with the rat that helped the first time now becoming the soaked rat. The remaining procedures were the same as in the door-opening sessions. There were six daily sessions in this phase.

Results and discussion

In the door-opening sessions, nine helper rats out of the 10 pairs showed door-opening behavior over the 12 sessions (Fig. 2a). The latency to door opening decreased over the course of the experimental sessions (Fig. 2b). A one-way analysis of variance (ANOVA) with repeated measures revealed significant differences between sessions

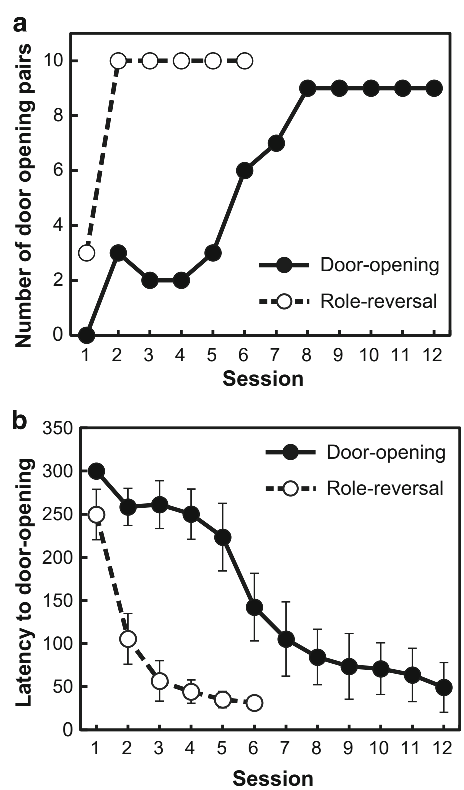

Fig. 2 Performance of helper rats in Experiment 1. **a** Number of rats that opened door as a function of the experimental session. *Closed circles* indicate the number of door-opening rats in the door-opening sessions. *Open circles* indicate data in the role-reversal sessions. **b** The latency for door-opening behavior as a function of the sessions. *Closed* and *open circles* indicate the door-opening latencies of the helper rats in the door-opening sessions and those in the role-reversal sessions, respectively. The *error bars* indicate the standard error of the means

($F_{11,99} = 17.34$, $P < 0.0001$). These suggest that the rats learned to help the distressed cagemate by opening the door.

After the door-opening sessions, we conducted three control tests (the pool, empty, and object tests) and compared the latency to door opening with that of the last trial of the door-opening sessions (Fig. 3). A one-way ANOVA with repeated measures revealed significant differences in experimental conditions ($F_{3,24} = 5.32$, $P < 0.01$), and post hoc tests using Ryan's method revealed that the latency of the last trial of the door-opening sessions was statistically shorter than that of the pool, empty, and object tests ($P < 0.05$).

In the water preference test, the rats showed a tendency to avoid water (Fig. 4). All rats were tested starting from both the ground and pool areas. Regardless of the starting point, the soaked (from ground: $t_9 = 10.43$, $P < 0.00001$; from pool: $t_9 = 25.34$, $P < 0.00001$) and helper rats (from ground: $t_9 = 19.17$, $P < 0.00001$; from pool: $t_9 = 18.06$, $P < 0.00001$) stayed in the pool for significantly less than the expected 150 s (the broken line in Fig. 4). These results indicate that the rats avoided stepping into water. For the spent time in the pool area, a two-way ANOVA for mixed design with a between-subject factor of group (2) and a within-subject factor of starting area (2) revealed a significant main effect of group ($F_{1,9} = 29.15$, $P < 0.0005$). This indicates that the soaked rats spent less time in the pool area than did the helper rats. There was neither a significant main effect of starting area ($F_{1,9} = 2.55$, *NS*) nor a group × starting area interaction ($F < 1$).

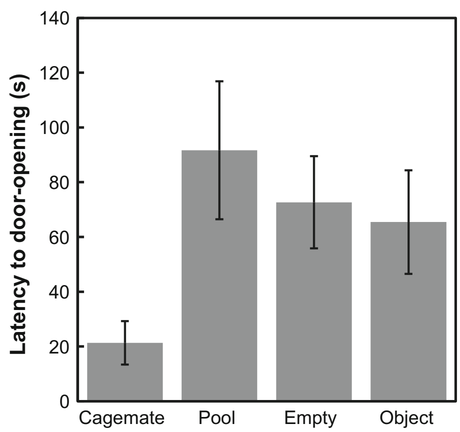

Fig. 3 Latencies for door-opening behavior in the last session of the door-opening sessions (cagemate) and the control tests (pool, empty, and object tests). The *error bars* indicate the standard error of the means

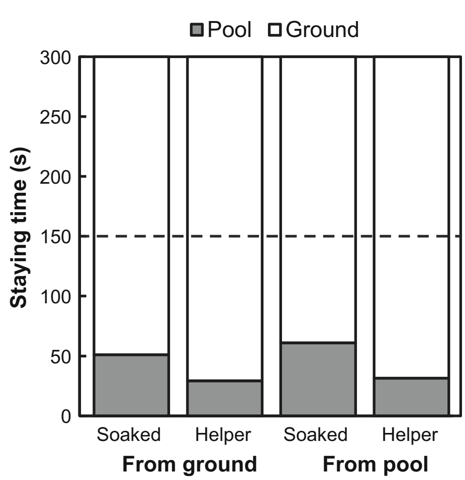

Fig. 4 Results of the preference test. The *white* and *shaded bars* indicate the time rats spent in the ground and pool areas, respectively. The *broken line* indicates the level of chance

To investigate the effects of prior experience of exposure to the water in the pool, we conducted the role-reversal sessions in which the roles of the helper and soaked rats were switched from the door-opening sessions. In the role-reversal sessions, all the helper rats (i.e., the soaked rats in the door-opening sessions) began to exhibit door-opening behavior more rapidly than the helper in the door-opening sessions (Fig. 2a); the rat that had no experience of being helped in the door-opening sessions helped its cagemate in the role-reversal sessions. The decrease in the latency of the door opening was also more rapid (Fig. 2b). The latency data were statistically analyzed using a two-way ANOVA for mixed design with a between-subject factor of group (2) and a within-subject factor of session (6). This revealed significant main effects of group ($F_{1,90} = 35.07$, $P < 0.0001$) and session ($F_{5,90} = 21.48$, $P < 0.0001$), and a significant group × session interaction ($F_{5,90} = 5.43$, $P < 0.0005$). This suggests that the helper rats in the role-reversal sessions, i.e., the soaked rats in the door-opening sessions, learned to open the door more rapidly than the helper rats in the door-opening sessions.

Experiment 2

The results of the control tests in Experiment 1 suggest that the existence of the soaking cagemate is important to generate the door-opening helping behavior. However, it is possible that the existence of the cagemate is simply enough to generate the behavior, i.e., it might not be necessary that the cagemate is in a distressed situation. To elucidate the importance of a cagemate being distressed, we investigated whether helper rats learned to open the door to allow the cagemate go through the partition when the cagemate was not in water.

Methods

Subjects

The subjects were 16 male, 10-week-old Sprague–Dawley rats (Japan SLC), weighing an average of 350 g at the beginning of the experiment. The housing condition was the same as that in Experiment 1.

Apparatus

The experiments were carried out in an experimental box made of black polyvinyl chloride boards. In this box, there were three areas (pool, ground, and food: Fig. 1b). In Experiment 2, we used the two of the three areas, the ground and food areas, but there was no food in the area. There was a hole in the partition 85 mm in diameter between the two areas. The hole of the other side in the ground area was covered.

Procedures

All rats were housed in pairs for 14 days to acclimate and handled for 5 min every other day by a male experimenter before starting the experimental sessions. After that, experimental sessions began. One of each pair of rats was randomly assigned as a helper, and the other was assigned to be a demonstrator rat. The other procedures were the same as in Experiment 1 except that the demonstrator rat was on the ground instead of in water.

Results and discussion

Out of the eight pairs of the rats, only one helper rat showed door-opening behavior over the 12 experimental sessions (Fig. 5a). The occurrence of the door-opening behavior was variable, i.e., one day the rat opened the door, but another day it did not. The latency of the door opening did not change over the course of the experimental sessions (Fig. 5b). A one-way ANOVA with repeated measures revealed no significant differences in the latencies between sessions ($F_{11,77} < 1$). These results suggest that the rats did not learn the door-opening behavior when their cagemate was not in a distressed situation and that a cagemate being distressed is necessary to generate the helping behavior.

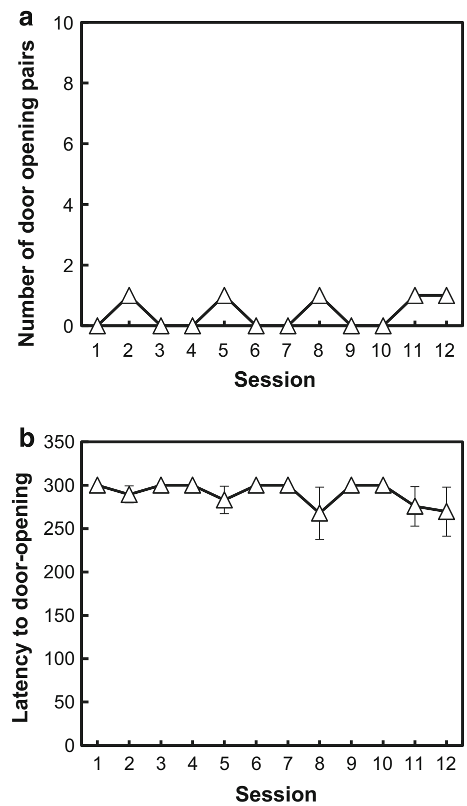

Fig. 5 Performance of helper rats in Experiment 2. **a** Number of rats that opened door as a function of the experimental session. **b** The latency for door-opening behavior as a function of the sessions. The *error bars* indicate the standard error of the means

Experiment 3

To investigate the relative value of the door opening to help a soaking cagemate, we carried out the choice test. In the choice test, the rats chose one of the two doors (Fig. 1b). One of the doors opened into the area in which the cagemate soaked in the pool, and the other opened into the area that contained the food reward. We supposed that the shaping method of the door-opening behavior might have an influence on the choice behavior. If the rats were shaped to open the door to help their cagemate before the choice test, it would induce them to open the door to help another rat rather than the door to food. Accordingly, we shaped the door-opening behavior using one of two procedures: opening the door to help the cagemate or opening the door to obtain food rewards. After the shaping, we carried out the choice test.

Methods

Subjects

The subjects were 20 male, 8-week-old Sprague–Dawley rats (Japan SLC), weighing an average of 291 g at the beginning of the experiment. They were housed in pairs as in Experiment 1. None of the rats were deprived of daily food and water.

Apparatus

The experiments were carried out in the same experimental box as Experiment 2. In this experiment, all of the three areas were used (pool, ground, and food: Fig. 1b). The ground area was in the middle of the box with a door on both sides. On one side of the middle ground area, there was a pool area, and on the other a food area. The water was 200 mm deep in the pool area. There was a hole in the partition 85 mm in diameter. The food area was similar to the ground area except that it had only one passable hole (Fig. 1b).

Procedure

All rats were housed in pairs for 14 days to acclimate and handled for 5 min every other day by a male experimenter before starting the experiment. We randomly divided the ten pairs of rats into two groups (five pairs each) and shaped the door-opening behavior using different procedures between the two groups. For one group, the door opening resulted in helping the cagemate, and for the other group, it resulted in food rewards in a cup, six pieces of chocolate cereal (Kellogg's Japan Chocowa^{TM}). In this shaping phase, two of the three areas of the experimental box were used. For the group in which the door-opening behavior was shaped by helping, the ground and pool areas were used. For the group in which the door opening was shaped by food reward, the ground and food areas were used. The learning criterion was to open the door within 60 s in three out of four consecutive sessions. After fulfillment of the learning criterion, we carried out the choice test using all three of the areas (Fig. 1b). In the choice test, the helper rats in the central ground area could open the doors at either side of the ground area. One of the doors opened into the area with the soaked cagemate, and another opened into the food rewards. We observed which door the rat opened first and measured the time it took to open the door. The test was ended 300 s after the rats opened both the doors or 600 s after the test started. One test trial was carried out per day, and in total, ten trials were carried out for each rat. The positions of the pool and ground areas were quasi-randomly changed (allowing the repetition <4 times) by rotating the entire apparatus. The numbers of each arrangement were the same (five trials each).

Results and discussion

The rats whose door opening was shaped by helping and those shaped by food reward required 19.6 ± 6.6 (mean $\pm$ standard deviation) and 12.8 ± 8.4 sessions to fulfill the learning criterion, respectively. The numbers of sessions were not significantly different between the two groups ($t_8 = 1.42$, *NS*).

The results of the choice test showed that the rats whose door-opening behavior was shaped by helping usually opened the door to the cagemate first and the rats whose door opening was shaped by the food rewards also opened the door to the cagemate first in half of the test trials (Fig. 6). In the rats shaped by helping, the proportion of opening the door to the cagemate first was significantly higher than the value expected if the rats had randomly chosen the door (50 %, the broken line in Fig. 6, $t_4 = 2.89$, $P < 0.05$). In the rats shaped by the food reward, the proportion of opening the door to the cagemate first was not significantly different from chance expectations (Fig. 6). However, if the rats' behavior depends only on their learning history, the proportion of first door opening to cagemates in the rats shaped by the food reward should be at the same level as the proportion of first door opening to food in the rats shaped by helping (22 %, the dotted line in Fig. 6). The observed value (48 %) was statistically higher than this expected value ($t_4 = 3.02$, $P < 0.01$).

The rats whose door opening was shaped by helping first opened the doors to the cagemate and food with average latencies of 13 and 6 s, respectively, in the trials in which they opened that door first (Table 1). The rats whose door opening was shaped by food reward opened the cagemate and food doors with average latencies of 8 and 16 s, respectively. A three-way mixed-design ANOVA with a

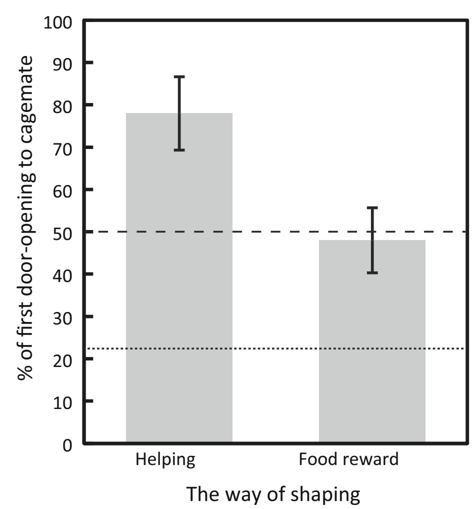

Fig. 6 Results of the choice test (Experiment 3). The *bars* indicate the mean percentage of trials in which the rats opened the door to the cagemate first. The *left* and *right bars* indicate the data for the rats whose door opening was shaped by helping the cagemate and by food reward, respectively. *Error bars* indicate the standard error of the means. The *broken line* indicates the level of chance. The *dashed line* indicates the percentage firstly opening the door to the food area among the rats that learned door opening by helping their cagemate (22 %)

Table 1 Latencies for door opening in the choice test

	Open the cagemate door first		Open the food door first	
	1st (cagemate)	2nd (food)	1st (food)	2nd (cagemate)
Trained by helping	13 (5)	70 (1)	6 (30)	254 (104)
Trained by food	8 (2)	73 (9)	16 (23)	265 (48)

The numbers in parentheses indicate standard error

between-subject factor of group (two ways of shaping) and within-subject factors of door (the first door opened: cagemate or food) and order (the first and second opening) revealed significant main effects of door ($F_{1,7} = 11.55$, $P < 0.05$) and order ($F_{1,7} = 22.21$, $P < 0.005$) and significant interaction of door × order ($F_{1,7} = 12.22$, $P < 0.05$). No other effects were statistically significant. The analyses of simple effect revealed that there was no difference in the latencies of the first choice, whereas there was a difference in the second-choice latencies. This suggests that the way the door-opening behavior had been shaped had no influence on the latency of the first door opening in the choice test. However, the latencies of the second door opening differed between the ways of shaping. When the rats opened the food door first, they ate the chocolate cereal for a while. It is conceivable that this eating behavior made the second door opening slow. Interestingly, we sometimes observed that the rats shaped by helping firstly opened the food door, secondly opened the cagemate door before consuming all of the food, and allowed the cagemate to share the food (25 % of the opportunities in the rats shaped by helping and 22 % in the rats shaped by food). Bartal et al. (2011) reported similar food sharing in rats in their similar experiment.

General discussion

The present study examined whether rats help their cagemates in an aversive situation. We used water to produce a situation of distress. The results in Experiment 1 showed that rats quickly learned to open the door to rescue their cagemate from the soaked situation. In addition, the three control tests (the pool, empty, and object tests) showed that the distressed cagemate is necessary to induce the door-opening behavior and that even if the door-opening behavior occurred with no cagemate, the latency was extremely prolonged when compared to that in the door-opening sessions. Similarly, in Experiment 2, the rats did not open the door when the cagemate was not distressed even when it was next to the door. These results suggest that the door-opening behavior was motivated to liberate the cagemate from the distressing situation and thus that rats can behave prosocially (Mogil 2012; Panksepp and Panksepp 2013). This is consistent with previous studies in which a free rat helped a restrained cagemate by opening the door of the restraining tube (Bartal et al. 2011, 2014).

In the present study, we utilized water to create an aversive situation. The results of the water preference test showed that rats seldom entered into the pool area and confirmed that rats dislike being soaked in water. This suggests that the present procedure using a pool of water is appropriate for creating an aversive situation.

In the role-reversal sessions, the rats that were soaked in water in the door-opening sessions learned the door-opening behavior much faster than rats without the experience of exposure to the water. This suggests that prior experience of being soaked in water sped up the acquisition of door-opening behavior. This modulation of learning by prior experience suggests that the helping behavior observed in the present study might be based on empathy (Atsak et al. 2011; Bartal et al. 2011; Mogil 2012; Panksepp and Panksepp 2013; Preston and de Waal 2002). It is also possible that learning about soaking as an aversive experience enhances helping behavior, similar to an incentive learning paradigm (Killcross and Balleine 1996). Observation of the cagemate opening the door may have also had some effect on performance in the role-reversal sessions. Rats learn some behavior through observing the behavior of other individuals (Heyes and Dawson 1990; Zentall and Levine 1972). The soaked rats might learn something related to door opening through observation of the helper cagemate during the door-opening session. By using experimentally naïve rats, we could clarify this issue in the future.

The results of the choice test revealed that in the majority of the test trials, the rats that learned to open the door by helping opened the door to their cagemate earlier than the door to the reward of chocolate cereal. The proportion that first opened the door to the cagemate among rats taught by helping was significantly higher than expected. For the rats that learned to open the door through a food reward, the same order of door opening was observed in half of the test trials. This proportion was not significantly different from chance; however, it was statistically greater than the proportion expected when calculated from the proportion of helping-trained rats opening the food door. The latencies of the first door opening were not different between the two groups. These results suggest that for all rats (those that learned door opening to obtain food rewards as well as those that learned it to help the cagemate), helping a distressed cagemate has a higher value than obtaining a food reward. This is consistent with the previous study that showed the rats were as quick to open the door of a restrainer containing their cagemate as they were in opening a door to an area containing chocolate chips (Bartal et al. 2011). The present study added information about the order of the choice, i.e., the rats shaped by helping chose the door to the cagemate first in most cases. In addition, the same order was observed in half of the rats whose learning was shaped by food and that had no experience of helping.

We used a different experiment box in the choice test from that in Experiment 1. The depth of the pool area used in the choice test was deeper than that in the door-opening sessions in Experiment 1. Deeper water might be more uncomfortable for rats. It might induce the result in the choice test; the door opening for helping was more valuable than that for food. However, the number of sessions needed to shape the door-opening behavior in the rats that learned it by helping was not statistically different from that in the rats that learned it by food reward. This suggests that the power of reinforcement for the door-opening behavior was not different between the two ways of shaping and that it is unlikely that deeper water caused the results in the choice test. However, the effect of the water depth is still a concern that we should address in future studies.

Bartal et al. (2011) reported that rats helped a cagemate even in a situation in which they did not have social contact and thus claimed that the door-opening behavior in their study suggests empathy in rats. In contrast, Silberberg et al. (2014) suggested that social contact is necessary to shape the helping behavior. Although the present study did not directly examine the effect of restriction of social contact, the rats in Experiment 2 did not open the door to allow their cagemate to go through the barrier when the cagemate was not in water. If the rats were motivated to have social contact with the cagemate, they would open the door even in this situation. This result suggests that the door-opening behavior could not be explained only by the motivation to have social contact. These findings are consistent with Bartal et al. (2011) and also suggest that rats experience empathy.

Empathy is thought to be divided into two major subcomponents: cognitive empathy and affective (emotional) empathy (de Waal 2008; Hoffman 2000). Cognitive empathy is the ability to understand the thoughts, feelings, and desires of other individuals, and emotional empathy is the ability to share the emotional states of other individuals. The empathic process observed in the present study falls into the category of emotional empathy. Studies on humans suggest that the anterior cingulate cortex and anterior insula are important brain regions for empathy, especially in situations of distress (Bernhardt and Singer 2012; Decety 2011). Oxytocin, a hypothalamic hormone, is one of the candidates that may be involved in empathic processes (Barraza and Zak 2009; Decety and Svetlova 2011; Shamay-Tsoory 2011). The experimental paradigm used in the present study could be a useful tool to examine the neural basis of empathy.

Recent studies have reported various social abilities in rodents, such as emotional contagion (Atsak et al. 2011; Chen et al. 2009; Langford et al. 2006), utilization of social cues for learning (Akyazi and Eraslan 2014; Knapska et al. 2010), cooperation (Rutte and Taborsky 2007; Viana et al. 2010), as well as helping (Bartal et al. 2011, 2014). The present study also provides one piece of evidence that suggests that rats are sensitive to a social cue. Although they should be interpreted carefully, studies of sociality such as empathy in rodents are important for understanding the underlying neural basis of prosocial behavior (Decety 2011; Decety and Svetlova 2011) as well as evolutionary aspects. We expect that the accumulation of knowledge from further studies will allow us to understand the cognitive abilities fundamental to sociality.

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Conflict of interest The authors declare no conflict of interest associated with this study.

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