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Food-carrying behavior increased under risk-approaching signal in rats (*Rattus norvegicus*)

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Abstract

Food-carrying behavior in foraging rats has been assumed to have an advantage to avoid risks by shortening time spent outside their nests. However, there is no experimental evidence for this. In the present study, food-carrying behavior for four sizes of food pellets (45, 100, 200, and 1000 mg) was measured under the presentation of risk-approaching signal (shock-conditioned tone) to verify whether food-carrying behavior is related to risk avoidance or not. The results supported the hypothesis as a whole that food-carrying behavior has close relation to risk avoidance. Food-carrying behavior was increased by the signal for all food sizes, especially statistically significant in the 200 mg condition, while it decreased to the baseline at early stage of the test. These findings are discussed in relation to predatory risk.

Keywords: Food-carrying behavior; Foraging; Hoarding; Predatory risk; Rats; Risk avoidance; Shock-conditioned tone

1. Introduction

Rats need to go out of their nests to search for food. When they find a piece of food, they must make a food-handling decision [15]: whether to eat it there or to carry it to the nest. This food-handling decision is known to be influenced by the size of and/or eating time for food. Rats generally eat a smaller piece of food at the food source but tend to carry a larger one as shown both in a field and semi-field study [10,18] and in laboratory experiments [11–17].

Eating food at the food source immediately satisfies hunger, while carrying food wastes time and energy [8,14]. In respect of energy intake rate [7], it would be plausible that rats eat food immediately whenever they find it. Nevertheless, the fact that food-carrying behavior increases in proportion to the food size implies there being other factors that influence food-handling decisions (i.e., "eating" or "carrying").

Foraging animals are always exposed to the risk of being victim of other predatory animals. For rodents, exposing themselves outside the nest leads to an increased probability of encountering hidden predators [8,9]. This is typically applicable to rats because of their ecological niche. Eating food at the food source inevitably prolongs time spent outside the nest. From this point of view, food-carrying behavior, especially for larger pieces of food, has an advantage to avoid risks by shortening time spent outside the nest though doing so prolongs food deprivation. Thus preceding findings that food-handling decision is influenced by the size of and/or eating time for food could be interpreted well in terms of the trade-off between hunger and risk avoidance.

It is found that rats less carry food and more eat it at the food source in the hungry condition than in the satiated condition [13]. This signifies that food-carrying behavior is influenced by hunger level. On the other hand, there is no experimental evidence that rats carry food in order to avoid risks. To verify this, food-carrying behavior must be observed to increase under risk situation. However, when a predator exists nearby in the foraging situation, rats stop foraging itself over a long period [1]. This suggests food-carrying behavior possibly reflect risk avoidance, not escape from confronting risk. On this account, the influences of

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predatory risk on food-carrying behavior should be examined under "risk-approaching" situation where predators do not exist at the moment but could emerge potentially.

Fanselow et al. [4] asserted the validity of using electric shock as a substitute for predators. They mentioned that rats cannot have gained specific mechanism to artificial electric shock in their evolutionary history, so that defensive responses to artificial threats (i.e., electric shock) should be mediated by common mechanism as to natural threats (i.e., predators). From such perspective, the present study used electric shock in place of predators. As mentioned above, however, the influences of predatory risk on food-carrying behavior should be examined under "risk-approaching" situation. To introduce approaching risk in a laboratory foraging situation, the classical conditionings between preceding tone and following shock was conducted preliminary to the food-carrying test. Thus the shock-conditioned tone was served as "risk-approaching signal" because it informs rats of risk arrival within a certain seconds. Then in the laboratory foraging situation, food-carrying behavior was observed under the presentation of shock-conditioned tone. It was presumed that food-carrying behavior would increase by the "risk-approaching signal" if rats carry food in order to avoid risks.

2. Materials and methods

2.1. Subjects

Subjects were 20 naive male Wistar–Imamichi rats aged 10–12 weeks. Mean body weight (±S.E.M.) was 346.6±9.0 g before the beginning of the experiment. The body weight of each rat was maintained at 85–90% level by food restriction throughout the experiment. Rats were housed in a temperature-controlled (23±2 °C) room on a 12-h light–dark cycle (lights on at 08:00 h). They were allowed free access to water in the colony room. The experiment was conducted during the light period. In all respects, maintenance and treatment of the animals were in accord with guidelines for animal care established by University of Tsukuba.

2.2. Apparatus

An elevated straight alley (60 cm above the floor) made of gray plastic boards was used in the food-carrying test (Fig. 1). It consisted of a start box (20×20 cm, 30-cm-high surrounding walls) regarded as the "nest", and an alley (10×200 cm, 2-cm-high sidewalls). A food well (3 cm in diameter, 1 cm in depth), regarded as the "food source", was set at the distal end of the alley. There was an opening (10×7 cm) between the start box and the alley, and rats were allowed to move freely between the start box and the alley. An infrared photo beam was adjusted to the position of 2.5 cm above the food well to detect rats' approaches to food. A

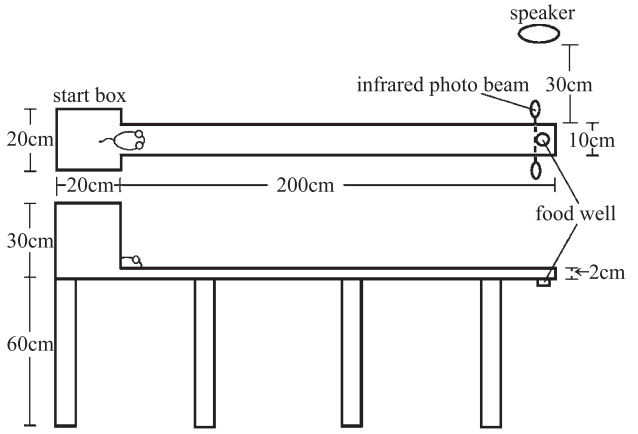

Fig. 1. The elevated straight alley used in the food-carrying test illustrated in the plane view (top) and the side view (bottom).

speaker was placed 30 cm aside the food well. The experimental room was illuminated with fluorescent lamps on the ceiling, and the brightness of the start box and the alley were 40 and 150 lx, respectively. The experimenter observed rats' behavior 200 cm aside from the start box. The behavior of rats in the start box was observed through a mirror on the ceiling.

A grid-floor box (30×25 cm, 25-cm-high surrounding walls) was used in the tone-shock conditioning. The right and left walls of the box were made of black plastic boards, and the other walls were made of transparent plastic boards. The same speaker as in the food-carrying test was placed 30 cm aside the conditioning box.

2.3. Procedure

2.3.1. Training

Days 1–3: each rat was exposed to the apparatus for 20 min a day. There was no food on the apparatus. Days 4–7: a rat was trained to get a 20 mg food pellet in the food well one trial a day. On Day 4, one pellet was put in the food well and three pellets were placed on the alley with 50-cm intervals each. A rat was trained to travel the alley through getting the pellets. On Days 5–7, pellets on the alley were gradually removed from the closest one to the start box (Day 5) to the most distal one from it (Day 7).

2.3.2. Baseline test

Days 8–12: the food-carrying test was carried out using four different sizes of food pellets (45, 100, 200, and 1000 mg). A rat experienced each one of the four sizes of pellets within daily four trials in a random order. In each trial, only one food pellet was put on the food well. A rat was allowed to leave the start box, travel to the food source, and choose whether to eat the pellet there or to carry it to the start box. One trial was finished when the rat returned to the start box. In the case the pellet was carried, the rat was allowed to stay in the start box till eating it up. The food-handling decision