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Feed efficiency, food choice, and food reward behaviors in young and old Fischer rats

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Abstract

Increased susceptibility to energy imbalance and anorexia in old age are risk factors for malnutrition during aging, but the underlying mechanisms are not well understood. Here, we explored changes in taste-guided hedonic value ("liking") and motivation to obtain ("wanting") palatable foods as potential mediators of age-associated anorexia and weight loss in old Fischer-344 rats. "Liking" as measured by the number of positive hedonic orofacial responses to sucrose and corn oil was not different in old compared with young rats. Taste-guided, low effort "wanting" as measured by the number of licks per 10 seconds was also not different, although old rats exhibited a slight oromotor impairment as revealed by significantly increased interlick intervals. Medium effort "wanting" as measured by performance in the incentive runway was significantly decreased in old versus young rats. Although decreased net running speed was partially accountable, significantly increased duration of distractions suggested additional deficits in motivation and/or reinforcement learning. Together with early satiation on corn oil but not sucrose in aged rats, these changes are likely to have resulted in the significantly greater sucrose preference of old rats in 12-hour tests, and may ultimately lead to reduced energy intake and weight loss.

Keywords: Aging; Anorexia; Palatability; Appetite; Gustation; Reward; Wanting; Licking; Learning

1. Introduction

Age-associated dysregulation of energy balance and anorexia may be 1 of the risk factors for malnutrition during aging (Morley, 1997; Roberts and Rosenberg, 2006). The physiological causes of anorexia of aging are largely unknown and likely multifactorial, involving both peripheral and central mechanisms, such as reduced sensory function, alterations in the hedonic qualities of food, increased gastrointestinal satiation signals, reduced metabolic rate and physical activity, changes in hormonal status, and alterations in central neurotransmitter control over hunger (Chapman, 2004; Morley, 1997). There are also changes in patterns of dietary intake and a reduction in the variety of food consumed in old age that are thought to further reduce energy intake (Fanelli and Stevenhagen, 1985; Roberts et al., 2005). Of particular interest is the fact that elderly individuals frequently complain of a loss of appetite (Morley and Silver, 1988; Olsen-Noll and Bosworth, 1989). Decreased appetite may be associated with a decrease in the pleasantness of food, which is indicative of inappropriate neural signaling within food-reward pathways.

Berridge and Robinson (2003) have outlined the potential psychological components that constitute the reward mechanisms in learning, liking, and wanting, corresponding to partially distinguishable neural mechanisms. With aging, alterations in gustatory evaluation, preference conditioning, appetitive motivation, or any combination may occur. There are data showing a decline in the hedonic qualities of food with aging in humans. This appears to result more from age-associated alterations in olfaction than alterations in

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taste (for review see Morley, 1997; Roberts and Rosenberg, 2006). Fewer data are available on changes in pleasantness of food with aging (de Graaf et al., 1994; de Jong et al., 1996). Although anecdotal, behavioral, and biochemical evidence suggest that the neural substrate for motivation might deteriorate in old age (for review see Dowling et al., 2008). These alterations can result in altered food preferences, which may reduce the quality and quantity of nutrients ingested.

In humans, age-related decline in food intake has been related to social, psychological, and medical causes. Control of appetite has an important psychological component, where food-reward pathways are modulated by cortical inputs derived from environment factors. This makes it difficult to distinguish between the effects of the environment and physiological factors implicated in age-associated decreases in food intake, mainly in those related to reward for food. Animal models of aging also reflect the decline in food intake and the deregulation of energy balance observed in humans both spontaneously and in response to disturbances in feeding (Gruenewald and Marck, 1996; Mattison et al., 2005; Toshinai et al., 2007; Wolden-Hanson, 2006).

In both humans (De Castro, 1993) and animals (Veyrat-Durebex and Alliot, 1997), the decrease in energy intake with aging is predominantly due to a decrease in fat calories with a small increase in the percent of calories ingested as carbohydrates (Islam et al., 1993; Whichelow and Prevost, 1996). These changes in macronutrient preference are associated with changes in metabolic requirements, but the possible implication of reward mechanism in this change, like changes of the hedonic impact of different nutrients with aging, is unknown. Other mechanisms that may have a significant impact on appetite and food intake in older people are physiological changes in gastrointestinal function (Parker and Chapman, 2004).

The present study was designed to evaluate the possible alterations in pleasantness and reward mechanisms for food in aged rats, which could reflect possible alterations in neural signaling within food reward pathways, and their potential relationship with age-associated decrease in food intake. Using several behavioral test paradigms to measure specific aspects of reward, including brief access lick behavior, orofacial taste reactivity as a measure for core "liking", and incentive runway behavior as a measure for "wanting", the relationship between age and food motivated behavior was assessed. In addition, micro- and macrostructure of licking sucrose solutions and corn oil emulsions was assessed in drinking-to-satiation tests and preference in 12-hour choice tests.

2. Methods

2.1. Animals

Young (3-month-old, $n = 10$) and old (18-month-old, $n = 10$) male Fischer-344 rats (F344; Harlan Industries, Indianapolis, IN, USA) were housed individually in stainless steel cages with a wire mesh floor in a climate-controlled room (22 ± 2 °C) on a 12:12-hour light-dark cycle with lights on at 7:00 AM. Food and water were available ad libitum except as specified below. Animals were fed a standard rodent diet (5001 Laboratory Rodent Diet, LabDiet, St. Louis, MO, USA; fat, 13.5 kcal%, carbohydrate, 58 kcal%; protein, 28.5 kcal%) as pellets.

The work was carried out over 16 weeks as outlined in Fig. 1; thus, at the end of the experiments the animals were 7 and 22 months old. Health status of the old animals was monitored throughout the experimental period by checking posture, mobility, tooth length, food intake, and body weight. All animal procedures were approved by the Institutional Animal Care and Use Committee at the Pennington Biomedical Research Center, and conformed to the guidelines of the National Institutes of Health.

2.2. Measurement of food intake, body weight, and body composition

Food intake was measured for either 12 or 24 hours. Chow intake was measured by weighing the food jars at the beginning and the end of the 12 or 24 hour periods. Spillage was subtracted from the intake. For each animal, body weight and chow intake were calculated as the average of 3 independent measurements.

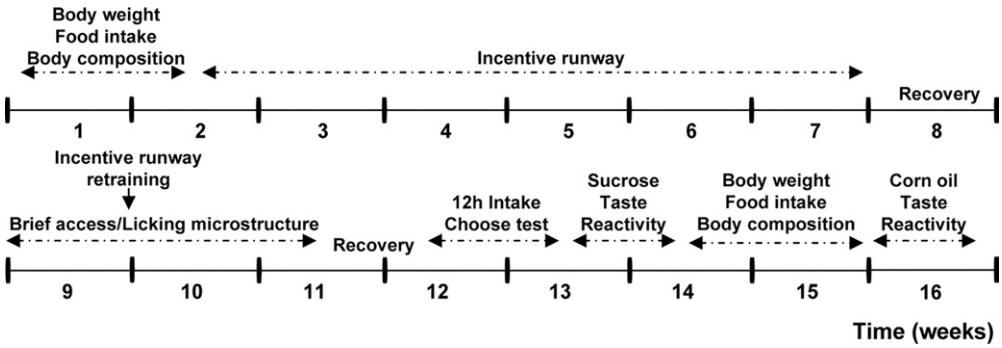

Fig. 1. Temporal sequence of measurements and test procedures.