Binge-type eating induced by limited access in rats does not require energy restriction on the previous day

Rebecca L. Corwin

Department of Nutritional Sciences, College of Health and Human Development, The Pennsylvania State University,
126 Henderson Building South, University Park, PA 16802 USA

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Abstract

This study was designed to determine if a limited access feeding protocol would induce binge-type eating when energy intake on the day before the binge was not reduced. Rats were assigned to four groups; all groups had continuous access to chow and water throughout the 4 wk study. In addition, access to optional shortening was provided as follows: (1) Control (C): no access to shortening, (2) Regular Shortening Access-7 (RSA7): 2-h access everyday, (3) Regular Shortening Access-3 (RSA3): 2-h access every Monday, Wednesday, and Friday, (4) Irregular Shortening Access (ISA): 2-h access on various days, such that the number of shortening access (binge) sessions equaled that of RSA3, but the last three sessions were each separated by 4 days. On the days prior to the last two binge sessions, RSA3 consumed significantly less energy than any other group (p < 0.05), but ISA intakes equaled those of Control and RSA7. During the last two binge sessions, intakes of RSA3 and ISA did not differ, and both groups consumed significantly more than RSA7 or Control (p < 0.05). These results demonstrate that binge-type eating can be induced by limiting access to an optional fatty food, and does not depend upon undereating on the previous day.

Keywords: Bingeing; Binge eating; Ingestive behavior; Food intake; Food restriction; Limited access; Periodic availability; Restricted access

Introduction

Previous research from our group has shown that limiting access to an optional source of dietary fat induces a binge-type pattern of eating in rats (Corwin et al., 1998; Dimitriou, Rice, & Corwin, 2000; Thomas, Rice, Weinstock, & Corwin, 2002). This intake pattern can be maintained for long periods of time, even though the animals have continuous access to chow and are never food-deprived. The basic finding is that intake during the limited access period is greatest in animals that have less access to the optional fat. Rats with infrequent access consume large amounts of the optional fat when it is provided, and compensate by voluntarily eating less of the continuously available chow on non-binge days. When rats only have access to the optional fat for 2-h on Mon, Wed, and Fri each week, intakes during the 2-h access period are very high, representing approximately 70% of control 24-h chow energy consumption. Furthermore, 24-h intakes on binge days significantly exceed those of controls. On non-binge days, on the other hand, 24-h intakes are significantly lower than those of controls. Thus, a binge/compensate intake pattern develops even though the rats are never deprived of food; only their access to the fat is restricted. The behavior of our animals, then, is similar in some ways to that of humans suffering from bingeing-related eating disorders (DSM-IV, 1994; Guertin, 1999).

One appeal of the limited access protocol is that food is always available and the animals are never formally food-deprived. However, since food is consumed in binge/compensate (overeat/undereat) cycles, it is possible that the excessive energy consumed during the binge is due to the previous day’s reduced food intake, rather than to the limited access schedule, per se. The present research was designed to determine if limiting access to an optional source of dietary fat would induce binge-type behavior, if energy intake on the day before the binge was not reduced.
Methods

Rats

Forty-two male Sprague Dawley rats, 61 days of age, weighing 297–350 g (Harlan, Indianapolis, IN), at the start of the study, were used. Rats were housed individually in hanging stainless steel wire cages in a temperature and humidity-controlled environment, and were given 6 days to adapt to the vivarium before starting the study. All rats were maintained on a continuously available, nutritionally complete, pelleted commercial laboratory rodent diet (Laboratory Rodent Diet 5001, PMI Feeds, Richmond, IN; percent of calories as protein: 28.05%, as fat: 12.14%, as carbohydrate: 59.81%; 3.3 kcal/g), that was placed at the front of the home cage throughout the study. That is, the rats were never food-deprived at any point. This diet will be referred to as the chow diet from this point on. Tap water was freely available from an inverted bottle attached to the front of the cage. A 12:12 light:dark cycle was used. The Pennsylvania State University Institutional Animal Care and Use Committee approved all procedures.

Procedure

At the end of the 6-day adaptation period, each rat was given overnight access to a jar of hydrogenated vegetable shortening (Crisco All-Vegetable Shortening, Procter and Gamble, Cincinnati, OH; percent of calories as fat: 100%; 9.2 kcal/g), clipped to the front of the cage, as well as the chow diet and water. This was done to prevent neophobia to the shortening during the remainder of the study. The rats were then matched for body weight and overnight shortening intake and assigned to four groups of 10–11 rats each (Table 1). All rats were then maintained on their respective diet protocols for the 4-week study.

The Control group (C, n = 10) had continuous access to the chow diet and water. No shortening was provided to this group at any time during the study, after the initial 24-h shortening access. Empty shortening jars were placed in these cages each day during the shortening access period to control for possible stimulus effects of moving the jars in and out of the cages.

The Regular Shortening Access-7 (RSA7, n = 10) group had 2-h access to shortening everyday of the week in addition to 24-h access to the chow diet and water. These rats had a total of 28 shortening access sessions.

The Regular Shortening Access-3 (RSA3, n = 11) group had 2-h access to shortening on Monday, Wednesday, and Friday each week. The chow diet and water were freely available at all times. Empty shortening jars were placed in the cages on the non-shortening days. These rats had a total of 12 shortening access sessions.

The Irregular Shortening Access (ISA, n = 11) group had 2-h access to shortening on various days, such that the total number of shortening access sessions equaled that of the RSA3 group (i.e. 12 sessions), but 4 days intervened between sessions 10 and 11, and between sessions 11 and 12. The goal of this manipulation was to bring energy intakes back up to Control levels on the days immediately prior to the last two shortening access sessions. As with the other groups, the chow diet and water were freely available at all times. Empty shortening jars were placed in the cages on the non-shortening days.

The C, RSA7, and RSA3 protocols are based upon previous work showing that the RSA3 protocol induces greater intakes during the 2-h access period than the RSA7 protocol, which induces greater intakes than C (Corwin et al., 1998; Dimitriou et al., 2000; Thomas et al., 2002). In addition, the RSA3 protocol previously has been shown to induce a binge/compensate intake pattern.

Shortening was provided 2-h prior to lights out as in our previous studies. Two-hour and 24-h intakes of shortening and chow were measured every day throughout the study by weighing the shortening and chow diet and subtracting the current food weight from the most recent previous food weight. Food intake was corrected for spillage, which was recovered after the 2-h feeding and 24-h feeding from the collection paper. Body weights were measured twice weekly.

Statistics

Data were analyzed using SYSTAT 5.2.1 for the Macintosh (SPSS, Inc., Evanston, IL). One-way analysis
of variance (ANOVA) and Tukey’s HSD post-hoc test were used to assess significant differences among the groups.

**Results**

Limiting access to shortening produced a binge/compensate eating pattern in the RSA3 and ISA groups, but not in the RSA7 group (Fig. 1). This pattern was well established during the second week in both the RSA3 and ISA groups.

On the days immediately prior to the last two binge sessions, the RSA3 group consumed significantly less energy than any other group (ANOVA $F(3, 38) = 9.205, p < 0.001$; Tukey’s HSD $p < 0.05$; Fig. 2). The energy intake of the ISA group, however, did not differ from the Control group or from RSA7. The protocol, therefore, met the goal of the investigation, i.e. in the ISA group, the last two binge sessions were not preceded by a day of undereating.

RSA3 and ISA consumed significantly more than RSA7 or Control during the last two shortening ‘binge’ sessions (ANOVA $F(3, 38) = 37.654, p < 0.001$; Tukey’s HSD $p < 0.05$; Fig. 3). Furthermore, even though energy intake prior to the binge sessions differed between RSA3 and ISA, consumption during the binge sessions did not differ significantly between these two groups.

In spite of the different intake patterns, total energy consumed across the 4-week study did not differ among the groups (ANOVA $F(3, 38) = 0.261, p = \text{n.s.}$; data not shown).

**Discussion**

The results obtained in this study demonstrate that binge-type behavior can be induced in non-food-deprived rats by
simply limiting access to a preferred fatty food, and that this type of excessive consumption is not dependent upon undereating on the previous day. The rats that had less frequent access to the shortening (RSA3 and ISA) consumed significantly more energy during the binge sessions than rats with more frequent access to the shortening (RSA7). Furthermore, although food intake on the days prior to the binge sessions differed between the RSA3 and ISA groups, both groups consumed significantly more than the RSA7 or Control group on the binge days. These findings confirm previous reports that limiting access to an optional food can induce bouts of excessive eating in non-food-deprived rats (Corwin et al., 1998; Dimitriou et al., 2000; Thomas et al., 2002). The present findings extend these previous reports by eliminating the confound of undereating the day before the binge sessions.

In our previous reports, binge sessions were separated by no more than 2 days, and body weight and body fat of the RSA3 group did not differ statistically from chow-only controls in studies that lasted from 6 to 8 weeks (Corwin et al., 1998; Dimitriou et al., 2000; Thomas et al., 2002). In the present study, the final binges in the ISA group were separated by 4 days, and, although not significant, the energy consumed by the ISA group during the last two binges was somewhat higher than that of the RSA3 group (see Fig. 3). This adds further strength to the argument that food-deprivation on the day prior to a binge session is not necessary for the effects of limited access to be expressed.

In addition, the present findings indicate that the interbinge interval can be longer than 48 h without affecting the size of the binge. The maximum amount of time that can intervene between binge sessions under limited access conditions and still maintain the behavior, however, has not yet been systematically examined. It is also not known if the binge size of the ISA group would have increased further, had the study lasted longer than 4 weeks, or if such a pattern of intake would have induced elevated cumulative intakes, as well as weight and/or fat gain across longer periods of time. Such studies would have particular relevance to human bingeing-related disorders, as binge-type eating patterns are usually maintained for extended periods of time, and are found with high frequency among patients seeking treatment for weight control (Marcus, 1993).

Nonetheless, the present data may have relevance to certain clinical situations, as well as to many fad diets, in which limiting access to particular foods is recommended without necessarily limiting energy intake. Whether such recommendations encourage binge-type eating when the restricted foods do become available has not been empirically assessed. However, in patients with bingeing-related eating disorders, binge foods typically consist of restricted items such as snacks and desserts (Guertin, 1999). Furthermore, studies in children suggest that limiting access to particular foods can stimulate subsequent intake and increase adiposity, even when the children are not energy-deprived (Fisher & Birch, 1999a, b, 2000, 2002). Limited access to preferred foods has also been proposed to contribute to erratic eating patterns and the prevalence of overweight in women experiencing food insecurity, even in the absence of food-deprivation (Townsend, Peerson, Love, Achterberg, & Murphy, 2001). By studying limited access under controlled laboratory settings in animals, we can develop a better understanding of its potential influence on human eating patterns and health, as well as some of its physiological and neurological consequences.

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References


