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Effect of limiting snack food variety on long-term sensory-specific satiety and monotony during obesity treatment

Hollie A. Raynor *, Heather M. Niemeier, Rena R. Wing

The Miriam Hospital Weight Control and Diabetes Research Center, Brown University Medical School, 196 Richmond Street, Providence, RI, RI 02903, United States

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Abstract

Limiting meal variety decreases hedonic ratings of eaten foods more so than non-eaten foods, demonstrating sensory-specific satiety. Exposure to a food over time decreases the food's hedonic ratings, indicating monotony. The effect of limiting food group variety over time on long-term sensory-specific satiety and monotony is unknown. Thirty overweight adults were randomized to one of two 8-week behavioral weight loss interventions. One condition limited snack food intake to one chosen snack food (reduced variety), while the other limited snack food intake to <1 serving/day (control), with no variety limit. In the reduced variety condition, hedonic ratings of the chosen snack food showed a decrease ($p < .05$) over time and decreased more ($p < .05$) than hedonic ratings of other snack foods. Weight loss (-7.4 ± 5.8 lb) occurred in both conditions. Limiting food group variety over 8 weeks produced long-term sensory-specific satiety and monotony. Future research should examine if limiting food group variety over an extended time affects intake and could be used as a technique in weight loss interventions.

Keywords: Diet; Variety; Sensory-specific satiety; Monotony; Snack foods; Weight loss

Experimental studies have shown that as a food is consumed during a meal, hedonic ratings for that food decrease more than for foods not being consumed (for a review, see Raynor & Epstein, 2001). This occurrence, called sensory-specific satiety, is predictive of subsequent intake of that food during that

* Corresponding author. Tel.: +1 401 793 8971; fax +1 401 793 8944.
E-mail address: hraynor@lifespan.org (H.A. Raynor).

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meal (Rolls, Rowe et al., 1981). For example, if participants are fed one food in the first course of a meal, liking for that food decreases relative to liking of other foods not served in the course and intake of that initial food is reduced in a second course compared to other foods not served in the first course (Rolls, Rolls, Rowe, & Sweeney, 1981). The change in hedonics is associated with the sensory qualities of the food, not with the postingestive consequences of the food (Sclafani, 1991).

While sensory-specific satiety has been shown to occur during a meal containing limited variety (Raynor & Epstein, 2001), there has been little experimental research examining the effect of limited dietary variety over an extended time period (i.e., several weeks) on long-term sensory-specific satiety. With limited dietary variety, the occurrence of long-term sensory-specific satiety should produce a greater reduction in hedonics of a food consistently consumed as compared to foods not as consistently consumed over time. A related phenomenon is monotony, where with increased exposure to a food over time, hedonic ratings of the consistently consumed food decrease (Hetherington, Pirie, & Nabb, 2002; Meiselman, deGraaf, & Lesher, 2000; Zandstra, deGraaf, & van Trijp, 2000), which often is associated with reduced intake of that food (Meiselman et al., 2000; Zandstra et al., 2000).

A hypothesized mechanism for sensory-specific satiety, and potentially monotony, is habituation (Hetherington & Rolls, 1996), in which there is a decrease in response to a stimulus with repeated presentations of the stimulus. This decrease is unrelated to other nonpsychological explanations such as fatigue. Thus, when the same food is repeatedly presented, food-related responses, such as salivation and hedonics, may decrease (Raynor & Epstein, 2001). A change in food cues (e.g., greater variety) should produce a recovery of food-related responses, thereby aiding in the resumption of eating (Swithers & Hall, 1994).

One method to reduce dietary variety over an extended time is to restrict food group variety. We have previously reported that, during a 6-month weight loss intervention, variety in energy-dense food groups decreases and is associated with reduced energy intake and greater weight loss (Raynor, Jeffery, Tate, & Wing, 2004). When food group variety is limited, long-term sensory-specific satiety and/or monotony may occur for those few foods still being consumed from the food group, thus reducing consumption of that food group.

The purpose of this investigation was to examine the effect of limiting food group variety over time on the development of both long-term sensory-specific satiety and monotony. To help improve adherence to the dietary prescription of limiting food group variety and to test this prescription within a clinically relevant situation, we limited variety of snack foods consumed within the context of an 8-week weight loss intervention. We compared the effect of limiting snack food variety to only one chosen snack food (reduced variety) to the effect of reducing daily servings of snack foods to <1, with no limit on snack food variety (control), on change in snack food hedonic ratings. We hypothesized that, over the 8 weeks, long-term sensory-specific satiety would occur only in the reduced variety condition, in which there would be a greater change in hedonic ratings of the consistently eaten chosen snack food as compared to other snack foods. Thus, when *different* snack foods were compared in the reduced variety condition, there would be a difference in the change in hedonic ratings of the snack foods over time. Moreover, the reduced variety condition would also demonstrate monotony, where a greater reduction in hedonic ratings of the consistently chosen snack food would occur in the reduced variety as compared to the control condition. As a result, the reduced variety condition would show a greater change in hedonic ratings of the *same* snack food than the control condition.

1. Methods

1.1. Participants

Participants were 27 females and 3 males, between the ages of 21 and 65 years, recruited through newspaper advertisements. Eligibility requirements included initial body mass index (BMI) between 25 and 40, which meets the National Heart, Lung, and Blood Institute's (NHLBI) guidelines for treatment of overweight and obesity in adults (NHLBI, 1998); free of food allergies to any foods used in the investigation; free of serious physical or psychiatric disorders, including those that might affect taste and appetite; not pregnant or nursing within the past 6 months and not planning to become pregnant during the intervention period; not participating in any weight loss programs or taking medication that could affect metabolism or body weight; and willingness to be randomly assigned to one of two treatment conditions. All participants provided written consent and the study protocol was reviewed and approved by the Miriam Hospital (Providence, RI).

1.2. Dietary intervention

To provide a rationale for and to improve adherence to the variety snack food manipulation, participants were instructed that the two snack food prescriptions used in the investigation would help reduce snack food intake, and thereby reduce caloric and fat intake and assist in weight loss. Participants were informed that the study was evaluating the effectiveness of the two snack food prescriptions. Following a baseline assessment, participants were randomized to one of two 8-week weight loss interventions, which manipulated variety of snack foods in the diet. Participants were given a daily caloric goal of 1200 to 1500 kcal/day, depending on baseline body weight (<200 lb vs. >200 lb), with 20% calories from fat, for weight loss.

For the reduced variety condition, participants chose one highly liked, commonly eaten (i.e., at least once per week) snack food (see Table 1 for a list of sample foods) to continue to include in the diet. Participants were asked to be very specific in their selection of snack food, identifying the actual flavor and type of snack food (i.e., strawberry ice cream rather than just ice cream). Snack foods were defined as those foods commonly eaten between meals or as desserts, high in energy density, and therefore

Table 1
Snack foods targeted in the intervention

Food group	Food item(s)
Bread, cereal, rice, and pasta	Baked goods (cookies, cakes, pies, doughnuts, sweet rolls, muffins, scones, pastries); granola, cereal, protein, and meal bars; graham crackers; flavored popcorn
Milk, yogurt, and cheese	Ice cream; pudding; frozen yogurt; ice milk; frozen dairy-based desserts
Meat, poultry, fish, dry beans, eggs, and nuts	Nuts
Fats, oils, and sweets	Candy; chocolate; chips and salty snacks (excluding pretzels and crackers); soft drinks (excluding diet drinks); punch (excluding low-calorie, like Crystal Lite™); coffees with extras added (example: carmel Mochiato from Starbucks™); flavored iced teas with calories; gelatin desserts; sherbet; frozen desserts (popsicle, fudgsicles)

generally reduced when a hypocaloric, low-fat diet is prescribed. The snack foods chosen by the 15 participants randomized to this condition fell into the following food categories: candy (5), cake (2), chips (2), ice cream (2), cookie (1), peanuts (1), buttered popcorn (1), granola bar (1). This condition was instructed to restrict their snack food consumption to this one chosen food during the 8 weeks. They were told to eat this food at least four times per week, in whatever amount desired, as long as daily calorie and fat gram goals were met. They were encouraged to consume the snack food at least four times per week to prevent feelings of deprivation. They were informed that reducing variety would help reduce intake from this food group, helping them to meet the other dietary goals. To control for the focus on snack foods in the reduced variety condition, the control condition also focused on snack foods, but instead of limiting variety, this condition reduced servings of snack food consumed to <1 per day, which is a standard recommendation used in behavioral weight loss interventions. Serving sizes of snack foods were based upon the Food Guide Pyramid (United States Department of Agriculture [USDA], 1996). The control condition was encouraged to eat as many different types of snack food as they wanted to prevent feelings of deprivation, as long as daily calorie and fat gram goals were met, during the 8 weeks of the intervention.

1.3. Treatment program

During the 8 weeks of the study, participants attended weekly group sessions, led by a doctoral-level clinical psychologist, that were designed to assist participants in adhering to their respective dietary interventions. In the sessions, participants were taught behavioral and cognitive skills, including self-monitoring, stimulus control, problem-solving, social support and assertiveness training, goal setting, cognitive restructuring, and relapse prevention. Participants kept eating diaries for the 8 weeks of the study. Weekly feedback was provided on participants' diaries regarding adherence to the dietary prescriptions. Participants were also instructed to gradually increase moderate-intensity physical activity to at least 150 min/week.

1.4. Measures

1.4.1. Hedonic ratings of snack foods

Hedonic ratings of snack foods were taken at weeks 1, 3, 5, 7, and 9. Participants were instructed not to eat for 2 h before these measures were taken. Participants were given 23 g of a SlimFast™ meal replacement bar (SlimFast™ Foods Company, West Palm Beach, FL) (110 kcal, 2.5 g fat) to eat, followed by 3 g samples of three different foods to taste. They rated how pleasant tasting each of the three foods were using a 100 mm visual analogue scale (VAS), anchored on the left with "very unpleasant" and on the right by "very pleasant". All participants tested two of the snack foods: one sweet food (Chips Ahoy™ chocolate chip cookies: Nabisco, Hanover, NJ) and one salty food (Tostitos™ tortilla chips: Frito-Lay, Inc., Plano, TX). Neither of these two foods was chosen by any of the participants in the reduced variety condition as their chosen snack food. For participants in the reduced variety condition, the final food was each participant's chosen snack food. Participants in the control condition were matched by age and BMI to one of the participants in the reduced variety condition, serving as a yoked control, and received the same snack food as their matched counterpart during each measure.

1.4.2. Dietary intake

To examine the effectiveness of the dietary manipulations, variety and servings from snack foods were assessed by 7-day food records completed at 0 and 9 weeks. Incomplete records were reviewed with participants by a registered dietitian. Number of different snack foods consumed and servings of snack food per week were calculated from the diaries. Additionally, the amount of calories consumed from snack foods per week were calculated from Nutritionist V (First Databank, San Bruno, CA) or food manufacturer information.

1.4.3. Diet satisfaction

The impact of the diet on changes in quality of life was assessed by the modified version of the Diabetes Quality of Life Measure (DQOL) (Delahanty, Hayden, Ammerman, & Nathan, 2002; The Diabetes Control and Complications Trial (DCCT) Research Group, 1988), which was administered at weeks 0 and 9. The DQOL is a 13-item self-administered questionnaire that measures satisfaction with and impact of the diet, including feelings of dietary restriction, on quality of life. Responses are based on a 5-point Likert-type scale. These scores were arithmetically transformed to a 100-point scale by subtracting the original score from 5 and then multiplying by 25. A score of 100 represents the highest possible quality of life score, while 0 is the lowest (Delahanty et al., 2002).

1.4.4. Snack food cravings

Snack food cravings were assessed by a Food Craving Questionnaire, based upon Pelchat and Schaefer's (2000) daily craving questionnaire, at weeks 0 and 9. Participants reported if they experienced food cravings in the past week and, if so, they listed the foods they craved, along with the frequency of occurrence. Percent of foods craved that were snack foods (number of snack foods craved / total number of foods craved × 100) along with percent of cravings from snack foods (number of snack food craving / total number of food cravings × 100) were calculated.

1.4.5. Binge eating and disinhibition

Binge eating was assessed at weeks 0 and 9 by the Binge Eating Scale (BES) (Gormally, Black, Daston, & Rardiin, 1982), a 16-item, self-administered questionnaire that measures eating behaviors and cognitions characteristic of individuals who binge eat. Scores below 17 indicate little or no problem with binge eating. Disinhibition, susceptibility to loss of control over one's eating, was measured by the Three Factor Eating Questionnaire (TFEQ) Stunkard and Messick (1985) at weeks 0 and 9. The disinhibiton factor of the TFEQ contains 16 items and higher scores on this questionnaire indicate greater disinhibition.

1.4.6. Demographic and anthropometric measures

At baseline, participants provided basic demographic information (e.g., age, education level, ethnicity, sex, and marital status). Trained personnel recorded height (in.) with a wall-mounted ruler at baseline and weight (lb) on a calibrated scale at 0 and 9 weeks, using standard procedures, and BMI (kg/m^2) was calculated from this information.

1.5. Statistical analysis

Independent *t*-tests and chi-square tests were used to compare the conditions on baseline characteristics, and paired *t*-tests compared baseline snack food ratings within each condition. For

analyses of hedonic ratings of snack foods, a mean hedonic rating of the two unchosen snack foods, chocolate chip cookie and tortilla chip, was determined at each time point, providing a composite snack food hedonic rating to which the chosen snack food hedonic rating could be compared (Hetherington, Rolls, & Burley, 1989; Rolls, Rowe, & Rolls, 1982). Changes in hedonic ratings of snack foods were analyzed in two ways. In the first analysis, examining long-term sensory-specific satiety, the change across time in hedonic ratings of the chosen snack food was compared to the change in hedonic ratings of the composite snack food in each condition separately. A repeated measures analyses of variance (ANOVA), with two within-subject factors, food (chosen snack food versus composite snack food), and changes in scores across time (change from week 1 to weeks 3, 5, 7, and 9), was conducted for the reduced variety condition, and then the same analysis was done for the control condition. The second analysis, examining monotony, compared the change in the hedonic ratings of the chosen snack food between the two conditions. This analysis used a repeated measures ANOVA, examining reduced variety versus their own yoked control and changes in scores across time (change from week 1 to weeks 3, 5, 7, and 9).

Changes across time in snack food intake, diet satisfaction, snack food cravings, binge eating, disinhibition, and weight were assessed by mixed repeated measures ANOVAS, with condition, reduced variety and control, as the between-subject factor, and time of measures, weeks 0 and 9, as the within-subject factor. Analyses were conducted using the intention-to-treat principle. Participants lost to follow up were assumed to have returned to their baseline value (a fairly conservative approach).

For analyses using repeated measures, where appropriate, Greenhouse–Geisser probability levels were used to adjust for sphericity. For significant outcomes, post-hoc comparisons with Bonferroni corrections were conducted. Statistical analyses were performed on SPSS for Windows, version 11 (SPSS, 2001).

2. Results

2.1. Demographics

No significant differences were found between the reduced variety ($n=15$) and control ($n=15$) conditions on any baseline characteristics (see Table 2). Of the 30 participants, 27 (90%) were Caucasian, 27 (90%) were female, 17 (56.7%) were married, and 16 (53.3%) were college graduates. Participants had a mean age of 49.5 (S.D.=9.9) years and a BMI of 32.2 (S.D.=3.3).

2.2. Dietary intake

In examining the adherence to the snack food prescriptions, there was a significant main effect of time, $F(1,28)=49.8$, $p<.001$, ES(η_p^2)=.64, for variety in snack foods consumed, with an overall reduction of -4.9 ± 4.0 different snack foods consumed per week. There was a trend towards significance ($p<.06$) for the interaction of condition × time, with the reduced variety condition reducing their weekly snack food variety more than the control condition (-6.3 ± 3.8 vs. -3.5 ± 3.8). At the end of the intervention, the reduced variety condition was consuming 2.9 ± 1.4 different snack foods per week, while the control condition consumed 4.5 ± 3.1 different foods. There was also a significant main effect of time for servings, $F(1,28)=38.0$, $p<.001$, ES(η_p^2)=.58, with a mean reduction of -11.1 ± 9.8

Table 2
Baseline characteristics of participants ($M \pm$ S.D.)

	Reduced Variety	Control
Age (years)	50.9 ± 8.4	48.2 ± 11.4
BMI (kg/m^2)	32.2 ± 2.8	32.3 ± 3.8
Number of different snack foods eaten/week	9.2 ± 3.3	8.1 ± 2.9
Number of servings of snack foods eaten/week	19.9 ± 11.0	18.7 ± 8.0
kcal from snack foods/week	2802 ± 1418	2866 ± 1044
Hedonic rating of cookie	74.3 ± 24.3	72.2 ± 21.5
Hedonic rating of chip	69.9 ± 25.3	74.5 ± 14.7
Hedonic rating of composite snack food[a]	72.1 ± 22.8	73.3 ± 13.3
Hedonic rating of chosen snack food	87.3 ± 21.0	72.7 ± 28.2

No differences were found between the conditions on any of the variables using independent *t*-tests. No differences were found between the chosen and composite snack foods ratings within conditions using paired *t*-tests. BMI = body mass index.
[a] Composite snack food rating is calculated as the mean of the cookie and chip hedonic ratings.

servings/week. At the end of the intervention, the control and reduced variety conditions were consuming 9.1 ± 7.3 and 7.3 ± 4.2 servings of snack foods/week, respectively. A main effect of time occurred for snack food calories per week, $F(1,28) = 37.7$, $p < .001$, ES(η_p^2) = .57, with a decrease of −1591 ± 1402 calories from snack foods eaten/week. At the end of the intervention, the control and reduced variety conditions had reduced calories consumed from snack foods per week by −1448 ± 1159 and −1732 ± 1637, respectively. See Fig. 1 for number of different foods, servings, and calories from snack foods eaten per week at 0 and 9 weeks for the two conditions.

2.3. Diet satisfaction and snack food cravings

The DQOL's impact subscale did not significantly change over weeks 0 to 9 (54.6 ± 15.6 vs. 57.1 ± 11.8), but a significant main effect of time was found for the satisfaction subscale, $F(1,28) = 44.8$, $p < .001$, ES(η_p^2) = .62, with satisfaction from the diet increasing from 35.7 ± 12.8 to 62.0 ± 18.7. There was no significance interaction of condition × time or main effect of condition.

A significant main effect of time was found for percent of foods craved that were snack foods, $F(1,28) = 5.3$, $p < .05$, ES(η_p^2) = .16, decreasing from 57.1 ± 39.5% to 34.3 ± 42.0%, and for percent of cravings that were for snack foods, $F(1,28) = 5.1$, $p < .05$, ES(η_p^2) = .16, decreasing from 59.0 ± 40.2% to 35.6 ± 42.8%. There was no significance interaction of condition × time or main effect of condition. There was also no effect of time or interaction of condition × time on total number of foods craved or total number of food cravings.

2.4. Binge eating and disinhibition

For binge eating, a significant main effect of time was found, $F(1,28) = 23.8$, $p < .001$, ES(η_p^2) = .46, with scores decreasing from 16.3 ± 7.7 to 11.6 ± 7.0. There was no significance interaction of condition × time or main effect of condition. There also was a significant main effect of time, $F(1,28) = 13.4$, $p < .001$, ES(η_p^2) = .32, and condition, $F(1,28) = 5.1$, $p < .05$, ES(η_p^2) = .16, for disinhibition. Disinhibition decreased from 10.4 ± 3.5 to 8.4 ± 3.6 and the reduced variety condition had greater disinhibition than the control condition (10.6 ± 3.8 vs. 8.2 ± 2.8). No significant interaction was found.

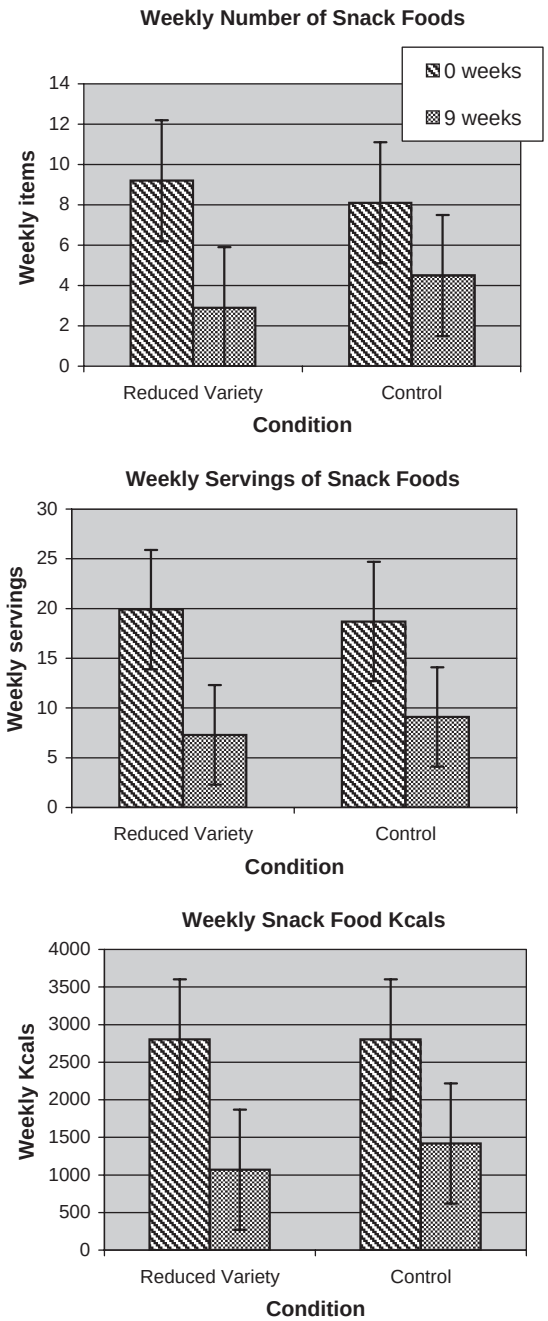

Fig. 1. Number of different, servings of, and kcal from snack foods consumed per week at 0 and 9 weeks in the reduced variety and control conditions ($M \pm$ S.E.M.). All variables significantly ($p < .05$) decreased over time.

2.5. Hedonic ratings of snack foods

Three participants were missing at least 1 week of hedonic measures; consequently, complete data for hedonic ratings was available for 12, rather than 15, pairs of participants. Analyses were conducted with all 15 pairs of participants, with missing values replaced by linear interpolation techniques (SPSS, 2001). Results were similar to analyses using the 12 pairs of participants with no missing data; thus, results for the 12 pairs of participants with complete data are presented. For the first analyses that examined long-term sensory-specific satiety, comparisons were made between the chosen versus composite snack food within each condition separately. The reduced variety condition showed a significant food x time interaction, $F(3,33)=3.0$, $p<.05$, ES(η_p^2) $=.21$. As shown in the upper graph (A) in Fig. 2, the chosen snack food showed a different pattern of change than the composite snack food. The chosen snack food showed a greater reduction ($p<.05$) in hedonic ratings from weeks 1 to 9 (-17.9 ± 11.5) than the hedonic ratings for the composite snack food (-3.4 ± 16.2). Whereas there was no reduction in hedonic ratings for the composite snack food, the chosen snack food demonstrated a reduction in hedonic ratings over time; ratings initially increased ($\pm2.7\pm14.2$ from weeks 1 to 3) followed by a steady decrease over time ($p<.05$), such that change in pleasantness ratings at weeks 7 and 9 (-12.3 ± 15.3 and -17.9 ± 11.5, respectively) were significantly below those at week 3. In contrast, there was no evidence of long-term sensory-specific satiety in the control condition; the analysis for the control condition found no significant main effect of food or time and no significant interaction for change in hedonic ratings of the chosen and composite snack food.

For the second analyses examining monotony, changes in hedonic ratings over time of the chosen snack food were compared between the reduced variety condition and their yoked controls. There was a significant condition × time interaction, $F(3,33)=4.1$, $p<.05$, ES(η_p^2) $=.27$. As shown in the lower graph (B) in Fig. 2, the reduced variety condition and the control condition demonstrated different patterns of change in hedonics ratings for the chosen snack food. As was demonstrated in the previous analysis, the reduced variety condition showed a steady decrease over time ($p<.05$) in hedonic ratings of the chosen snack food. There was no significant change in hedonic ratings of the chosen snack food over time in the control condition.

2.6. Weight loss

For weight loss, a significant main effect of time was found, $F(1,28)=49.8$, $p<.001$, ES(η_p^2)$=.64$, with a reduction of -7.4 ± 5.8 lb. There was no significant difference in weight loss between the two conditions. The dietary prescription provided to participants should have produced a mean weight loss of approximately 8 lb, which was met.

3. Discussion

The occurrence of sensory-specific satiety within an eating session has been well documented in experimental studies, such that hedonic ratings for a food eaten in a meal decrease more than hedonic ratings for foods not eaten in the meal (Raynor & Epstein, 2001; Rolls, Rolls et al., 1981; Rolls, Rowe et al., 1981). Increased exposure to a food over time also reduces a food's hedonic ratings, indicating monotony, and is associated with reduced intake of the food (Meiselman et al., 2000; Zandstra et al.,

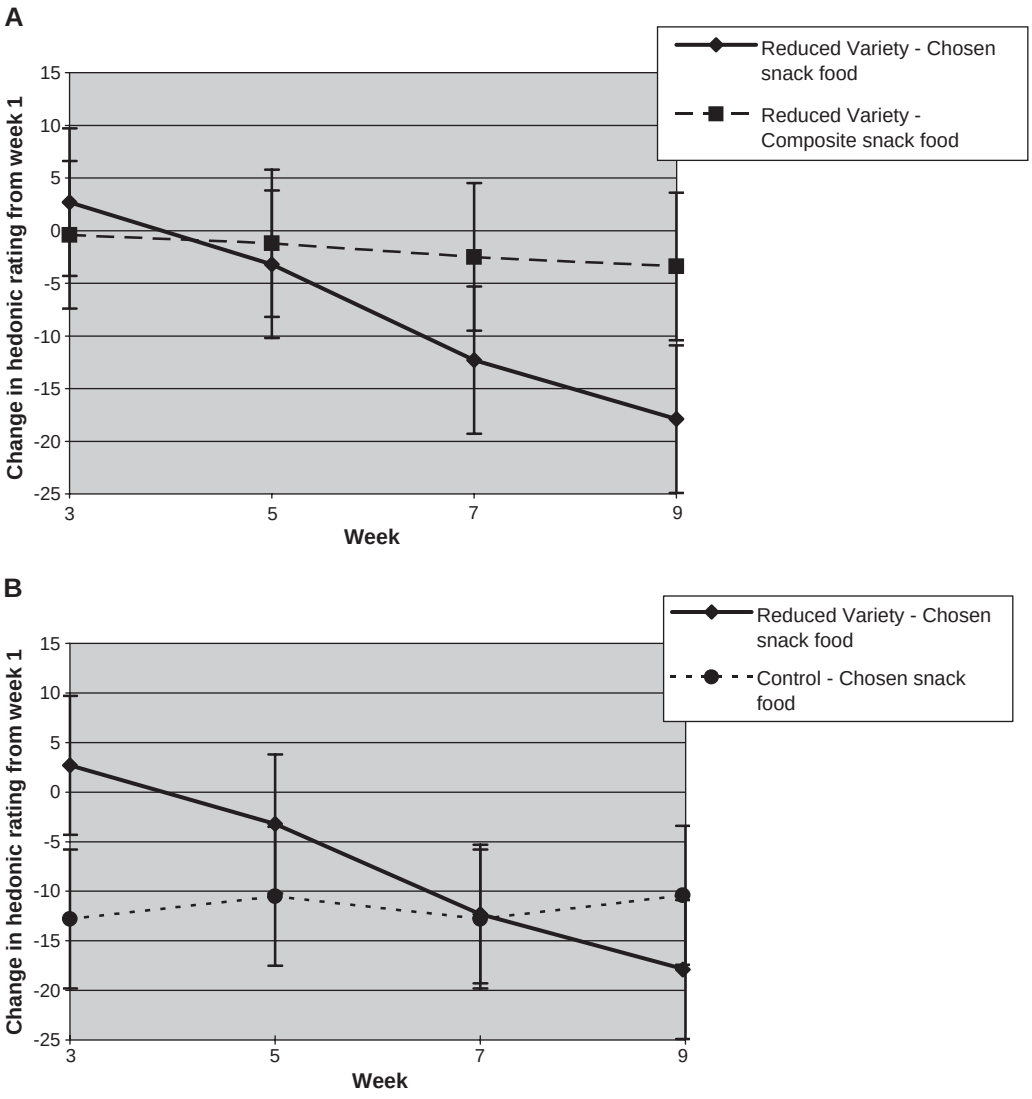

Fig. 2. (A) Changes in hedonic ratings during treatment for the chosen and composite snack food in the reduced variety condition ($M \pm$ S.E.M.), with the chosen snack food showing a greater reduction ($p < .05$) in ratings from weeks 1 to 9 than the composite snack food. (B) Changes in hedonic ratings during treatment for the chosen snack food in the reduced variety and control conditions, with the reduced variety condition showing a significant ($p < .05$) reduction in hedonic ratings from week 3 to weeks 7 and 9 ($M \pm$ S.E.M.).

2000). However, much less is known about the impact of limiting dietary variety over an extended time on both long-term sensory-specific satiety and monotony. Therefore, this investigation examined the effect of limiting snack food variety over 8 weeks on these two phenomena.

As predicted, when snack food variety was limited over 8 weeks, long-term sensory-specific satiety occurred, in which hedonic ratings of the consistently eaten snack food decreased more than hedonic ratings of other snack foods in the reduced variety condition. For this hypothesis, a within condition

comparison of change in hedonic ratings of *different* snack foods was conducted. The control condition, where snack food variety was not limited and consistent exposure to the same snack food did not occur, did not produce this outcome. Moreover, as hypothesized, the reduced variety condition demonstrated a greater decrease in hedonic ratings of the chosen snack food over time than the control condition, demonstrating monotony. For this hypothesis, a between condition comparison, reduced variety to yoked control participant in control condition, of change in hedonic ratings of the *same* snack food was conducted.

The results of this study provide preliminary support for the occurrence of both long-term sensory-specific satiety and monotony through limited food group variety over several weeks. It is important to note that this is the first randomized trial consisting of an extended time period (8 weeks versus a meal) in which the effect of limiting variety on the occurrence of both long-term sensory-specific satiety and monotony have been examined. Moreover, other factors that may influence hedonic ratings of food, such as preoccupation with specific foods and weight loss, were controlled for in both conditions.

Since both long-term sensory-specific satiety and monotony occurred within this trial, these results suggest that these two phenomena, which are measured and defined differently, may have the same underlying mechanism. One proposed mechanism by which sensory-specific satiety, and potentially monotony, occurs is through habituation (Swithers & Hall, 1994). In the reduced variety condition, the pattern of change in hedonic ratings of the chosen snack food followed a biphasic pattern similar to what has previously been described as sensitization and habituation (Swithers, 1996). Hedonic ratings of the consistently eaten snack food initially increased (sensitization) and then decreased over time with continued exposure to the chosen snack food (habituation) (Swithers, 1996). The reduced variety condition failed to demonstrate the biphasic pattern in change in hedonic ratings for other snack foods, and the control condition did not show this pattern of change for the chosen snack food. The initial increase in hedonic ratings of the chosen snack food in the reduced variety condition may be a consequence of the food being highly liked. Highly liked foods can be more resistant to decreases in hedonics than less liked foods (Hetherington et al., 2002; Meiselman et al., 2000).

While long-term sensory-specific satiety and monotony for the chosen snack food appeared to occur in reduced variety condition, the reduction in hedonics for the chosen snack food did not translate into a significantly greater reduction in overall calories from snack foods at the end of the 8-week intervention in the reduced variety as compared to the control condition. When sensory-specific satiety occurs for a food consumed in an eating bout, consumption of that food within that eating bout decreases (Raynor & Epstein, 2001). Monotony has also been associated with reduced intake (Meiselman et al., 2000; Zandstra et al., 2000). Thus, the occurrence of long-term sensory-specific satiety and monotony would be expected to decrease intake of the consistently eaten chosen snack food in the reduced variety condition, thereby causing an overall decrease in snack food consumption relative to the control condition. Potentially, a longer study or a larger sample may have been able to find significant differences in snack food intake between the conditions.

If limiting variety within a food group leads to long-term sensory-specific satiety and monotony, and is consequently accompanied by a decrease in intake from the food group, this technique may aid in the adoption of a low-energy diet and help with weight loss and weight loss maintenance. Experimental research in animals has demonstrated that a diet with limited variety reduces energy intake and body weight (Raynor & Epstein, 2001). In longitudinal analyses, we found that during a standard weight loss intervention prescribing a low-calorie, low-fat diet, decreases in variety in energy-dense food groups (e.g., high-fat and/or high-sugar snack foods) occurred, and that a greater decrease in variety in snack

foods was associated with larger reductions in caloric and percent dietary fat intake, and greater weight loss (Raynor et al., 2004). Additionally, data from the National Weight Control Registry (NWCR), comprised of successful weight loss maintainers who have lost >30 lb and sustained that loss for at least 1 year, indicate that registry participants' diets have less high-energy-dense food group variety than even the most successful weight losers' (individuals who lost >7% of weight during a 6-month weight loss intervention) diets. For example, registry participants report consuming only 19% (1.7 out of 9 items) and 12% (1.6 out of 13 items) of the food items from the Block food frequency questionnaire (Block et al., 1986) that can be categorized into the Fats, oils, and sweets group of the Food Guide Pyramid (FGP) (USDA, 1996) or high-fat foods (>30% energy from fat) from the five main food groups of the FGP (USDA, 1996), respectively. This suggests that limiting high-energy-dense food group variety may assist with long-term weight loss maintenance (Raynor, Jeffery, Phelan, Hill, & Wing, 2005).

Research using diets with extreme limitations in variety indicates that these diets appear to be very good at producing short-term weight loss. A diet with the most severe limitation in variety is the liquid diet, which has been shown to reduce intake and produce weight loss even when a hypocaloric prescription is not provided and weight loss is not the goal (Cabanac & Rabe, 1976; Hashim & Van Itallie, 1956; Spiegel, 1973). Recently, another diet that severely limits variety, the low-carbohydrate diet, has been used in randomized trials for weight loss (Brehm, Seeley, Daniels, & D'Alessio, 2003; Foster et al., 2003; Samaha et al., 2003; Yancy, Olsen, Guyton, Bakst, & Westman, 2004). Short-term outcomes (6 months) show greater reductions in energy intake and weight loss with the low-carbohydrate diet as compared to a hypocaloric, low-fat diet that contains greater variety (Brehm et al., 2003; Samaha et al., 2003). However, at 12 months, weight loss is equivalent between the two diets (Foster et al., 2003; Stern et al., 2004). These studies suggest that long-term adherence to diets with extreme limitations in dietary variety may be difficult. In contrast to these approaches which drastically limit dietary variety across many food groups, targeting one problematic food group (snacks) and reducing variety only in this group may increase acceptance long-term. Indeed, in this investigation, the reduced variety condition did not report increases in snack food cravings, feelings of dissatisfaction with the diet, binge eating, or disinhibition.

Although the reduced variety condition reported a greater decrease in the number of different snack foods eaten than the control condition, with this outcome showing a trend towards significance ($p < .06$), the reduced variety condition reported eating a mean of 2.9 (range = 1 to 6) different snack foods/week, which was greater than the goal of one snack food per week. While this was unlikely to have affected the primary outcome of this study, as sensory-specific satiety and monotony are more likely to occur with *more* limited variety, it may have affected the ability of long-term sensory-specific satiety and/or monotony to significantly influence overall intake from this food group. At the end of the intervention, participants suggested that adherence to the limited variety prescription may have been easier if two snack foods, allowing for one sweet and one salty choice, rather than one, were included in the prescription. Consequently, more research investigating the effects of limiting snack food variety during a behavioral weight loss intervention is required to improve long-term adherence to this dietary prescription and to determine its effectiveness on reducing energy intake and long-term weight loss.

The primary limitations of this study were the relatively brief follow-up period and small sample size. Although we were able to demonstrate long-term sensory-specific satiety and monotony via changes in the hedonic ratings of the chosen snack food, a longer follow-up would have allowed us to determine participants' ability to adhere long-term to the prescription of limiting snack food variety, and examine the change in hedonic ratings of the chosen snack foods over time. If adherence to the limited variety

prescription continued, it would be expected that the hedonic ratings of the chosen snack foods would have continued to decrease over time and that this greater decrease should lead to a greater reduction in consumption of snack foods.

In regards to examining the effect of the dietary prescription on caloric intake from snack foods, the reduced variety condition decreased their weekly intake of calories from snack foods by 63%, while the control condition decreased their weekly caloric intake of these foods by 51%. With the sample size used in this investigation, we had less than 20% power to detect a difference in caloric intake from snack foods at the end of treatment between the two conditions. Thus, a larger sample would provide more power to detect a significant difference in caloric intake from snack foods between the two dietary prescriptions.

This investigation examined the effect of limiting snack food variety on long-term sensory-specific satiety and monotony within the context of a structured weight loss intervention. Thus, to determine if this outcome is a general, rather than context-specific, principle, future investigations should examine the effects of limiting snack food variety in other populations (e.g., normal weight individuals, overweight individuals not attempting weight loss, and individuals with differing levels of dietary restraint).

In conclusion, this study found that limiting snack food group variety in the context of a brief behavioral weight loss intervention produced greater reductions in hedonic ratings of a consistently eaten snack food more so than other snack foods not consistently consumed (long-term sensory-specific satiety), and that hedonic ratings of the consistently eaten snack food decreased over time (monotony). Future research needs to examine the ability of these phenomena to influence intake and the effectiveness of limiting variety in an energy-dense food group as a technique for use in a weight loss intervention.

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