

# Dietary restraint and control over "wanting" following consumption of "forbidden" food.

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# Dietary Restraint and Control Over “Wanting” Following Consumption of “Forbidden” Food

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Eating behavior can be influenced by the rewarding value of food, i.e., “liking” and “wanting.” The objective of this study was to assess in normal-weight dietary restrained (NR) vs. unrestrained (NU) eaters how rewarding value of food is affected by satiety, and by eating a nonhealthy perceived, dessert-specific food vs. a healthy perceived, neutral food (chocolate mousse vs. cottage cheese). Subjects (24NR age = 25.0 ± 8.2 years, BMI = 22.3 ± 2.1 kg/m<sup>2</sup>; 26NU age = 24.8 ± 8.0 years, BMI = 22.1 ± 1.7 kg/m<sup>2</sup>) came to the university twice, fasted (randomized crossover design). Per test-session “liking” and “wanting” for 72 items divided in six categories (bread, filling, drinks, dessert, sweets, stationery (placebo)) was measured, before and after consumption of chocolate mousse/cottage cheese, matched for energy content (5.6 kJ/g) and individual daily energy requirements (10%). Chocolate mousse was liked more than cottage cheese ( $P < 0.05$ ). After consumption of chocolate mousse or cottage cheese, appetite and “liking” vs. placebo were decreased in NR and NU ( $P < 0.03$ ), whereas “wanting” was only decreased in NR vs. NU ( $P \leq 0.01$ ). In NR vs. NU “wanting” was specifically decreased after chocolate mousse vs. cottage cheese; this decrease concerned especially “wanting” for bread and filling ( $P < 0.05$ ). To conclude, despite similar decreases in appetite and “liking” after a meal in NR and NU, NR decrease “wanting” in contrast to NU. NR decrease “wanting” specifically for a nonhealthy perceived, “delicious,” dessert-specific food vs. a nutritional identical, yet healthy perceived, slightly less “delicious,” “neutral” food. A healthy perceived food may thus impose greater risk for control of energy intake in NR.

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## INTRODUCTION

Currently, appetite research is paying attention to the food reward system as an important non-homeostatic regulator of human eating behavior. Unraveling this reward system may help us to understand the factors that influence the excessive food intake associated with obesity (1–3).

According to the incentive salience theory the process of reward consists of two components, i.e., “liking” and “wanting,” controlled by different brain mechanisms (4). “Liking,” under control of opioids, is the hedonic or affective component and refers to the pleasure derived from orosensory stimulation of food (5,6). “Wanting,” under control of dopamine, is the motivational incentive component and refers to appetite or craving or the motivation to obtain food (1,4–7). Although “liking” and “wanting” often go hand-in-hand, humans may want less liked food items, cultivated as a habit, as for instance restrained eaters do: they cognitively restrict their food intake to lose weight or to prevent weight gain (6,8). Furthermore, in research on drug addiction it was observed that drug addicts are driven to take drugs without “liking” their effects (9,10). Taking the above into account, it is of importance to

differentiate between the influences of “liking” and “wanting” on food intake. Moreover, since successful dietary restrained eaters control their food intake more cognitively, it is relevant to assess whether effects of “liking” and “wanting” on food intake differ between dietary restrained and unrestrained eaters (11).

The aim of this study was to assess in normal weight, and thus successful, dietary restrained eaters (NR) vs. normal-weight dietary unrestrained (NU) eaters how the rewarding value of food in general, and more specific in terms of “liking” and “wanting,” is affected by satiety, and by the consumption of food items that may differ in rewarding value: a dessert-specific food item, i.e., chocolate mousse, vs. a dessert nonspecific, “neutral” food item, i.e., cottage cheese. A computer test for measurement of “liking” and “wanting,” developed and validated in a previous study, was used (12). That previous study indicated that chocolate mousse was mostly described as a delicious but less healthy food item and cottage cheese as a healthy food item, whereas both items had the same energy content and density (12). Foods classified as unhealthy are commonly considered to contain more calories than healthy foods (13).

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However, the caloric content of “healthy foods” may often be underestimated and consumption of those foods may influence the amount of intake or the subsequent food choice, possibly related to individual differences (14). Hence, a possible pitfall for restrained eaters to regulate their body weight cognitively may be the consumption of “healthy foods.” Consumption of those foods may not be perceived as a violation of adhering to their dieting rules and consequently may lead to an increased food and energy intake.

Therefore, consumption of chocolate mousse and cottage cheese, as examples of nonhealthy respectively healthy food items, may exert different effects on the rewarding value of foods, in terms of “liking” and “wanting,” in NR subjects compared with NU subjects. We hypothesize that in NR subjects in contrast to NU subjects consumption of chocolate mousse may prevent further “wanting” of foods, whereas consumption of cottage cheese may still allow further “wanting” of foods.

## METHODS AND PROCEDURES

### Subjects

Fifty normal-weight white subjects (15 males and 35 females, age  $24.9 \pm 8.0$  years (mean  $\pm$  s.d., range 18–51 years)) with a BMI of  $22.2 \pm 1.9$  kg/m<sup>2</sup> (mean  $\pm$  s.d., range 18.9–25.3 kg/m<sup>2</sup>) participated in this study. They were recruited by advertisements in local newspapers and on notice boards at the university and hospital. Subjects underwent an initial screening including measurement of body weight and height and completion of a questionnaire related to health, use of medication, smoking behavior, alcohol consumption, and physical activity. Eating behavior was analyzed using a validated Dutch translation of the Three-Factor Eating Questionnaire (TFEQ) which measures three components: “cognitive restraint of eating” (factor 1), “disinhibition of restraint” (factor 2), and “hunger” (factor 3) (8). Factor 1 describes the tendency to which individuals attempt to cognitively control their food intake. Factor 2 describes the loss of control over eating in situations that make the cognitive control more difficult. Factor 3 describes the subjective feeling of hunger (8). On the basis of the median for the TFEQ scores in the south of the Netherlands, subjects were characterized as unrestrained when dietary restraint scores were  $<9$ , and as restraint when scores were  $\geq 9$ . Subjects were characterized as having low disinhibition when disinhibition scores were  $<5$ , and as having high disinhibition when scores were  $\geq 5$  (15). Subjects were divided into two groups according to their scores on the TFEQ restraint scale: a restrained group ( $n = 24$ ) and an unrestrained group ( $n = 26$ ). All subjects gave written informed consent by the start of the first test day. The study was approved by the Medical Ethical Committee of the Maastricht University.

### Study design

The study was conducted in a randomized crossover design as described previously by Lemmens *et al.* (12). All subjects came to the university twice in a fasted state, between 08:00 and 10:00 AM. The test sessions differed only in the presentation of the test meal: either chocolate mousse or cottage cheese.

The test session started by filling out visual analogue scales (VAS) on appetite-related parameters. Subsequently the researcher gave the instructions on the computer test for measurement of “liking” and “wanting.” After completing the computer test, subjects had to consume the entire test meal. Immediately postingestion subjects filled out the VAS and completed the computer test again.

### Appetite profile

One hundred unit VAS (mm) were used to assess the appetite profile. The scales were anchored with “not at all” at one end and “extremely” at the other end, and combined with questions on feelings of hunger,

thirst, fullness, satiety, desire to eat, and on “liking,” “wanting,” creaminess, and fullness of taste of chocolate mousse and cottage cheese. These VAS were completed in the fasted and satiated state. Subjects received a full tutorial on the completion of VAS on appetite-related parameters before the start of the actual experiment.

### Test meal

The test meal consisted of either chocolate mousse or cottage cheese (both 0.6 MJ/100 g; energy % protein/carbohydrate/fat: 21/29/50) and a glass of water (250 ml). The amount of chocolate mousse or cottage cheese given to the subjects corresponded to 10% of their daily energy requirements. For each subject the daily energy requirements were calculated by multiplying the basal metabolic rate by the appropriate physical activity factor (1.5–1.8, derived from the screening questionnaire (16)). The basal metabolic rate (MJ/day) was calculated according to the equation of Harris–Benedict (17). On average subjects received 1.1 MJ (range 0.8–1.6 MJ) of chocolate mousse or cottage cheese, corresponding to an average of 204 g (range 148–290 g). This range was present because of the subject-specific calculated energy requirements. The order of presentation of the test meal was randomized across the subjects to prevent any order effects. Factorial ANOVA analysis showed no significant effect of the order the subjects received the test meals, chocolate mousse or cottage cheese, respectively, concerning the data of the appetite profile measurements and of the “liking” and “wanting” computer test ( $P > 0.05$ ).

### “Liking” and “wanting” computer test

The computer test described and validated by Lemmens *et al.* was used to measure the rewarding value, i.e., “liking” and “wanting,” for 72 items divided in six categories: bread, filling, drinks, dessert, sweets, and stationery (nonfood alternative as placebo) (12). Each category contained 12 items. The 72 items were presented as photographic stimuli on a computer screen (13-inch Mac Book; Apple, Cupertino, CA).

During the “liking” part of the computer test subjects had to indicate their relative preference of paired items within and between categories, resulting in a ranking of “liking” of the items per category and of the categories.

During the “wanting” part of the computer test subjects had to work to earn items to choose from by playing memory games. For each category of items subjects played a five by five memory game (12 pairs of items) followed by the indication of the items subjects wanted to acquire at that moment. If for example eight pairs of items would be found in the memory game of the sweets category, then eight randomly selected sweets would be offered to choose from. Subjects could choose zero, one or two items per category. They were instructed to choose the items while keeping in mind that all the chosen items would be offered to them and had to be eaten completely. The chosen items obtained a score equal to the number of pairs of items found in the memory game, representing the motivation or workload for the chosen items. Items not chosen obtained a score of zero. Per category the sum of the scores of the items was calculated and represented the “wanting” score for each category. The reward consisted primarily of magnitude of food variety offered per category and secondarily of meal size consisting of the number of different categories that subjects had worked for.

### Statistics

Data were analyzed using StatView 5.0 (SAS Institute, Cary, NC). Differences over time (pre- to postmeal), between subject groups (NR and NU) and between conditions (chocolate mousse and cottage cheese) were analyzed using paired Student’s *t*-tests, factorial ANOVA or two-factor ANOVA with repeated measures. The Wilcoxon signed-rank test was used to detect differences in the ranking of “liking” of items within each category between pre- to postmeal. Simple linear regression models were used to determine relationships between TFEQ scores and mean “wanting” for items from any category. All tests were

two-sided and differences were considered significant at  $P < 0.05$ . Values are expressed as mean  $\pm$  s.e. of the mean (s.e.m.).

## RESULTS

### Subject characteristics

The characteristics of the subjects are summarized in **Table 1**. Age, BMI, and disinhibition scores did not differ between NR and NU subjects. NU subjects had a higher height and body weight compared with NR subjects ( $P < 0.01$ ), due to the higher number of men in the NU group. NR subjects had higher dietary restraint and lower feeling of hunger scores than NU subjects ( $P < 0.05$ ).

Taking gender into account, male subjects showed an overall higher mean “wanting” for items from any category in the chocolate mousse and cottage cheese condition ( $P < 0.02$ ). There was no gender effect for the change in appetite profile ratings and in “liking” and “wanting” scores pre- to postconsumption of chocolate mousse and cottage cheese. Therefore

those results for male and female subjects were analyzed together.

### Appetite profile

**Table 2** shows the results of the appetite profile measurements by means of VAS in the NR and NU subject groups and in the chocolate mousse and cottage cheese condition. In both subject groups high ratings for hunger, thirst, and desire to eat and low ratings for fullness and satiety were measured at the start of the two test sessions, confirming their fasted state. In both subject groups and both conditions, meal consumption induced a decrease in hunger, thirst, and desire to eat and an increase in fullness and satiety ( $P < 0.02$ ), confirming that subjects were in a satiated state when they fulfilled the second computer test.

Both subject groups liked chocolate mousse more than cottage cheese ( $P < 0.02$ ) and perceived chocolate mousse as more full of taste than cottage cheese ( $P < 0.01$ ), before as well as after consumption of both food items. In both groups and both conditions “liking” and “wanting” for chocolate mousse respectively cottage cheese decreased after test meal consumption ( $P < 0.03$ ).

The changes in these appetite profile parameters pre- to postconsumption did not differ between NR and NU subjects ( $P > 0.1$ ).

### “Liking” and “wanting” computer test

**Table 3** shows the results of the computer test for relative “liking” between categories in NR and NU subjects and in the chocolate mousse and cottage cheese condition. Pre- to postconsumption of chocolate mousse, a change in the ranking of “liking” of the six categories was observed in both subject groups, thereby decreasing the dessert category and increasing placebo, the stationery category ( $P < 0.001$ ). This decrease in “liking” for the dessert category was larger in the chocolate mousse condition than in the cottage cheese condition in both

**Table 1** Characteristics of normal-weight dietary restrained (NR) and unrestrained (NU) subjects

	NR ( <i>n</i> = 24; 3m/21f)	NU ( <i>n</i> = 26; 12m/14f)	<i>P</i> <sup>a</sup>
Age (years)	25.0 $\pm$ 8.2	24.8 $\pm$ 8.0	1.0
Height (cm)	168.6 $\pm$ 8.1	177.6 $\pm$ 7.1	<0.001
Body weight (kg)	63.3 $\pm$ 7.9	69.9 $\pm$ 7.1	<0.01
BMI (kg/m <sup>2</sup> )	22.3 $\pm$ 2.1	22.1 $\pm$ 1.7	0.8
Dietary restraint score	11.8 $\pm$ 2.2	4.0 $\pm$ 2.4	<0.001
Disinhibition score	4.5 $\pm$ 2.0	4.5 $\pm$ 2.0	1.0
Feeling of hunger score	3.2 $\pm$ 1.8	4.7 $\pm$ 2.9	0.04

Values are means  $\pm$  s.d.

m, male; f, female.

<sup>a</sup>*P* value: differences between subject groups (factorial ANOVA).

**Table 2** Mean ( $\pm$ s.e.m.) visual analogue scale ratings (mm) for hunger, thirst, desire to eat, fullness, satiety, “liking,” “wanting,” creaminess and fullness of taste, pre- and postmeal (CM, chocolate mousse; CC, cottage cheese), in normal-weight dietary restrained (NR) and unrestrained (NU) subjects

	NR ( <i>n</i> = 24)				NU ( <i>n</i> = 26)				<i>P</i> <sup>a-d</sup>
	CM pre	CM post	CC pre	CC post	CM pre	CM post	CC pre	CC post	
Hunger	55.6 $\pm$ 5.5 <sup>a</sup>	7.0 $\pm$ 1.4 <sup>a</sup>	58.0 $\pm$ 4.5 <sup>a</sup>	20.3 $\pm$ 4.2 <sup>a</sup>	59.6 $\pm$ 4.1 <sup>a</sup>	15.3 $\pm$ 3.8 <sup>a</sup>	61.2 $\pm$ 4.4 <sup>a</sup>	27.6 $\pm$ 4.4 <sup>a</sup>	<0.001
Thirst	59.8 $\pm$ 3.9 <sup>a</sup>	44.5 $\pm$ 4.9 <sup>a</sup>	57.1 $\pm$ 4.3 <sup>a</sup>	40.5 $\pm$ 4.5 <sup>a</sup>	57.4 $\pm$ 4.8 <sup>a</sup>	38.9 $\pm$ 5.7 <sup>a</sup>	63.0 $\pm$ 3.0 <sup>a</sup>	36.2 $\pm$ 5.8 <sup>a</sup>	<0.01
Desire to eat	57.9 $\pm$ 5.3 <sup>a</sup>	8.3 $\pm$ 1.8 <sup>a</sup>	60.5 $\pm$ 4.1 <sup>a</sup>	26.8 $\pm$ 5.0 <sup>a</sup>	60.5 $\pm$ 4.3 <sup>a</sup>	19.0 $\pm$ 3.7 <sup>a</sup>	66.1 $\pm$ 4.2 <sup>a</sup>	31.2 $\pm$ 4.7 <sup>a</sup>	<0.001
Fullness	22.9 $\pm$ 3.1 <sup>a</sup>	84.5 $\pm$ 2.0 <sup>a</sup>	18.5 $\pm$ 2.8 <sup>a</sup>	74.3 $\pm$ 4.5 <sup>a</sup>	17.7 $\pm$ 3.8 <sup>a</sup>	73.3 $\pm$ 4.5 <sup>a</sup>	13.3 $\pm$ 3.2 <sup>a</sup>	62.7 $\pm$ 4.7 <sup>a</sup>	<0.001
Satiety	25.2 $\pm$ 3.7 <sup>a</sup>	80.9 $\pm$ 3.6 <sup>a</sup>	24.6 $\pm$ 3.3 <sup>a</sup>	70.4 $\pm$ 4.8 <sup>a</sup>	15.6 $\pm$ 2.5 <sup>a,d</sup>	77.3 $\pm$ 3.7 <sup>a,d</sup>	16.4 $\pm$ 3.6 <sup>a,d</sup>	60.7 $\pm$ 3.8 <sup>a,d</sup>	<0.02
“Liking”	70.9 $\pm$ 2.4 <sup>ab</sup>	60.4 $\pm$ 3.6 <sup>ac</sup>	48.3 $\pm$ 4.7 <sup>ab</sup>	37.4 $\pm$ 5.6 <sup>ac</sup>	65.7 $\pm$ 5.5 <sup>ab</sup>	55.7 $\pm$ 6.4 <sup>ac</sup>	50.3 $\pm$ 4.5 <sup>ab</sup>	41.6 $\pm$ 5.4 <sup>ac</sup>	<0.03
“Wanting”	46.1 $\pm$ 4.5 <sup>a</sup>	8.3 $\pm$ 2.4 <sup>a</sup>	43.1 $\pm$ 5.4 <sup>a</sup>	13.6 $\pm$ 3.4 <sup>a</sup>	49.9 $\pm$ 5.7 <sup>a</sup>	11.5 $\pm$ 3.8 <sup>a</sup>	42.8 $\pm$ 5.0 <sup>a</sup>	13.0 $\pm$ 3.6 <sup>a</sup>	<0.001
Creaminess	71.9 $\pm$ 4.2	70.1 $\pm$ 5.1	71.5 $\pm$ 4.5	76.2 $\pm$ 4.8	73.3 $\pm$ 4.4	74.7 $\pm$ 4.5	71.7 $\pm$ 4.4	75.1 $\pm$ 3.1	>0.2
Fullness of taste	77.8 $\pm$ 2.9 <sup>b</sup>	73.4 $\pm$ 4.5 <sup>c</sup>	57.7 $\pm$ 5.4 <sup>b</sup>	51.9 $\pm$ 5.8 <sup>c</sup>	80.6 $\pm$ 3.2 <sup>b</sup>	78.2 $\pm$ 3.5 <sup>c</sup>	63.3 $\pm$ 5.3 <sup>b</sup>	58.6 $\pm$ 6.5 <sup>c</sup>	<0.01

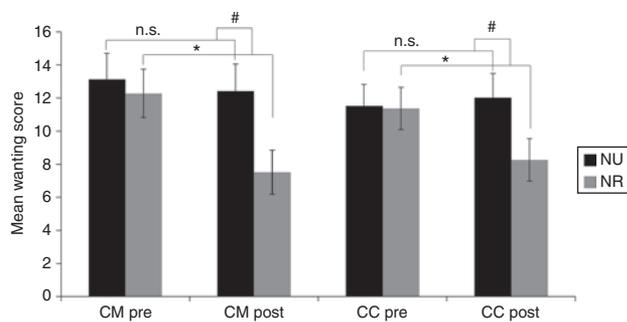
<sup>a-d</sup>*P* value: <sup>a</sup>differences pre- to postmeal (*t*-test). <sup>b</sup>Differences between CM and CC condition premeal (*t*-test). <sup>c</sup>Differences between CM and CC condition postmeal (*t*-test). <sup>d</sup>Differences concerning the difference in satiety pre- to postconsumption in the CM vs. CC condition in NU subjects (two-factor ANOVA with repeated measures).

**Table 3** Relative “liking” score between categories (mean ± s.e.m.) pre- and postconsumption of chocolate mousse (CM) and cottage cheese (CC) in normal-weight dietary restrained (NR) and unrestrained (NU) subjects

Category	NR (n = 24)								NU (n = 26)								P <sup>a,b</sup>
	R	CM pre	R	CM post	R	CC pre	R	CC post	R	CM pre	R	CM post	R	CC pre	R	CC post	
Bread	1	76.2 ± 15.5	1	67.8 ± 13.8	1	72.6 ± 14.8	1	72.1 ± 14.7	1	69.6 ± 13.6	1	66.5 ± 13.0	1	74.5 ± 14.6 <sup>a</sup>	1	65.0 ± 12.8 <sup>a</sup>	0.02
Filling	5	34.5 ± 7.1	6	33.8 ± 6.9	4	37.7 ± 7.7	6	32.4 ± 6.6	5	37.8 ± 7.4	6	25.3 ± 6.9	5	38.0 ± 7.4	6	34.6 ± 6.8	>0.05
Drinks	3	47.3 ± 9.7 <sup>a,b</sup>	2	58.2 ± 11.9 <sup>a,b</sup>	3	52.1 ± 10.6 <sup>b</sup>	3	49.3 ± 10.1 <sup>b</sup>	3	45.4 ± 8.9	3	48.1 ± 9.4	3	47.1 ± 9.2	4	46.0 ± 9.0	<0.02
Dessert	2	62.0 ± 12.7 <sup>a,b</sup>	4	45.1 ± 9.2 <sup>a,b</sup>	2	62.6 ± 12.8 <sup>b</sup>	2	55.4 ± 11.3 <sup>b</sup>	2	65.6 ± 12.9 <sup>a,b</sup>	2	51.8 ± 10.2 <sup>a,b</sup>	2	61.7 ± 12.1 <sup>b</sup>	2	59.8 ± 11.7 <sup>b</sup>	<0.05
Sweets	4	38.3 ± 7.8	5	37.9 ± 7.7	5	36.0 ± 7.4	5	39.8 ± 8.1	4	43.9 ± 8.6	4	46.6 ± 9.1	4	45.1 ± 8.8	3	48.6 ± 9.5	>0.09
Stationery	6	28.8 ± 5.9 <sup>a</sup>	3	50.2 ± 10.3 <sup>a</sup>	6	24.8 ± 5.1 <sup>a</sup>	4	44.1 ± 9.0 <sup>a</sup>	6	25.3 ± 5.0 <sup>a</sup>	5	41.3 ± 8.1 <sup>a</sup>	6	24.4 ± 4.8 <sup>a</sup>	5	39.9 ± 7.8 <sup>a</sup>	<0.001

R, rank number.

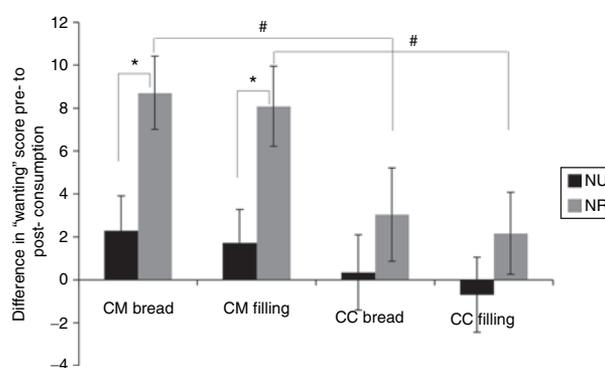
P<sup>a,b</sup>: P value: <sup>a</sup>differences pre- to postmeal (t-test), <sup>b</sup>Differences concerning the difference in relative “liking” pre- to postconsumption in the CM vs. CC condition (two-factor ANOVA repeated measures).



**Figure 1** Mean “wanting” score (±s.e.m.) for items from any category pre- and postconsumption of chocolate mousse (CM) and cottage cheese (CC) in normal-weight dietary restrained (NR) and unrestrained (NU) subjects. \* $P < 0.01$  for differences pre- to postmeal (t-test), # $P < 0.01$  for differences between NR and NU subjects concerning the difference in “wanting” pre- to postconsumption of CM and CC (factorial ANOVA).

subject groups ( $P < 0.05$ ). Pre- to postconsumption of cottage cheese an increase in the ranking of “liking” of stationery ( $P < 0.001$ ) was observed in both subject groups. The changes in the ranking of “liking” of the categories pre- to postconsumption of both test meals did not differ between subject groups ( $P > 0.1$ ). The ranking of “liking” of the items within each category did not change significantly in both conditions and in both subject groups ( $P > 0.1$ ).

**Figure 1** shows mean “wanting” for items from any category in NR and NU subjects and in the chocolate mousse and cottage cheese condition. In both conditions there was a significant time by group interaction (pre/postmeal × NR/NU subject group) for mean “wanting” for items from any category ( $P \leq 0.01$ ). Mean “wanting” for items decreased pre- to postconsumption of chocolate mousse and cottage cheese in the NR subjects ( $P < 0.01$ ) but not in the NU subjects. Therefore, the decrease in mean “wanting” for items from any category pre- to postconsumption of chocolate mousse ( $P < 0.01$ ) and



**Figure 2** Difference in mean “wanting” score (±s.e.m.) pre- to postconsumption of chocolate mousse (CM) and cottage cheese (CC), for the bread and filling category in normal-weight dietary restrained (NR) and unrestrained (NU) subjects. \* $P \leq 0.01$  for differences between NR and NU subject groups (factorial ANOVA), # $P < 0.05$  for differences between CM and CC condition (two-factor ANOVA repeated measures).

cottage cheese ( $P = 0.01$ ) was higher in NR subjects than in NU subjects.

Moreover (**Table 4**), in NR subjects consumption of chocolate mousse induced a decrease in “wanting” for bread ( $P < 0.001$ ), filling ( $P < 0.001$ ), drinks ( $P = 0.01$ ), dessert ( $P = 0.01$ ), and stationery ( $P = 0.03$ ). Consumption of cottage cheese induced a decrease in “wanting” for drinks ( $P < 0.01$ ) and dessert ( $P = 0.02$ ). The decrease in “wanting” for bread and filling pre- to postconsumption of chocolate mousse and cottage cheese was higher in the chocolate mousse condition compared with the cottage cheese condition ( $P < 0.02$ ; **Figure 2**). NU subjects did not show a significant change in “wanting” per category in both conditions. Consequently, the decrease in “wanting” for bread and filling pre- to postconsumption of chocolate mousse was higher in NR subjects compared with NU subjects.

**Table 4** "Wanting" score per category (mean  $\pm$  s.e.m.) pre- and postconsumption of chocolate mousse (CM) and cottage cheese (CC) in normal-weight dietary restrained (NR) and unrestrained (NU) subjects

Category	NR				NU				<i>P</i> <sup>a-d</sup>
	CM pre	CM post	CC pre	CC post	CM pre	CM post	CC pre	CC post	
Bread	16.0 $\pm$ 1.7 <sup>a,b,e</sup>	7.3 $\pm$ 1.5 <sup>a-c,e</sup>	13.6 $\pm$ 1.7 <sup>b</sup>	10.6 $\pm$ 1.5 <sup>b</sup>	14.8 $\pm$ 1.6 <sup>e</sup>	12.5 $\pm$ 1.7 <sup>c,e</sup>	13.6 $\pm$ 1.8	13.3 $\pm$ 1.9	<0.05
Filling	16.5 $\pm$ 1.8 <sup>a,b,e</sup>	8.5 $\pm$ 1.9 <sup>a,b,e</sup>	13.8 $\pm$ 1.6 <sup>b</sup>	11.7 $\pm$ 1.7 <sup>b</sup>	15.2 $\pm$ 1.8 <sup>e</sup>	13.5 $\pm$ 1.9 <sup>e</sup>	13.2 $\pm$ 1.7	13.9 $\pm$ 1.9	<0.04
Drinks	14.7 $\pm$ 1.9 <sup>a</sup>	11.0 $\pm$ 1.6 <sup>a</sup>	15.2 $\pm$ 1.8 <sup>a,f</sup>	9.8 $\pm$ 1.6 <sup>a,f</sup>	14.7 $\pm$ 1.7	14.3 $\pm$ 1.7	12.1 $\pm$ 1.5 <sup>f</sup>	13.7 $\pm$ 1.7 <sup>f</sup>	<0.02
Dessert	12.7 $\pm$ 1.8 <sup>a</sup>	8.1 $\pm$ 1.8 <sup>a</sup>	12.6 $\pm$ 2.0 <sup>a</sup>	8.3 $\pm$ 1.9 <sup>a</sup>	13.3 $\pm$ 2.0	12.6 $\pm$ 2.0	12.3 $\pm$ 1.9	11.8 $\pm$ 1.9	<0.03
Sweets	5.4 $\pm$ 1.8	4.5 $\pm$ 1.6 <sup>c</sup>	6.2 $\pm$ 1.8	4.5 $\pm$ 1.5	10.1 $\pm$ 1.9	10.0 $\pm$ 2.0 <sup>e</sup>	9.5 $\pm$ 2.0	8.4 $\pm$ 1.8	0.04
Stationery	8.4 $\pm$ 2.2 <sup>a,e</sup>	5.7 $\pm$ 1.8 <sup>a,c,e</sup>	7.3 $\pm$ 2.0	5.1 $\pm$ 1.9 <sup>d</sup>	10.7 $\pm$ 2.0 <sup>e</sup>	11.6 $\pm$ 2.1 <sup>c,e</sup>	9.0 $\pm$ 2.1	11.1 $\pm$ 2.1 <sup>d</sup>	<0.05

*P*<sup>a-d</sup>: *P* value: <sup>a</sup>differences pre- to postmeal (*t*-test). <sup>b</sup>Differences concerning the difference in "wanting" pre- to postconsumption in the CM vs. CC condition (two-factor ANOVA repeated measures). <sup>c,d</sup>Differences between NR and NU subjects postconsumption of CM<sup>c</sup> and CC<sup>d</sup> (factorial ANOVA). <sup>e,f</sup>Differences between NR and NU subjects concerning the difference in "wanting" pre- to postconsumption of CM<sup>e</sup> and CC<sup>f</sup> (factorial ANOVA).

A simple linear regression model showed a negative relationship between dietary restraint scores (factor 1 TFEQ) and mean "wanting" for items from any category after chocolate mousse consumption ( $R^2 = 0.1$ ,  $P = 0.04$ ).

## DISCUSSION

The objective of this study was to assess pre- to postmeal changes in the rewarding value of food, in terms of "liking" and "wanting," as a function of dietary restraint. Two contrasting, but otherwise similar and isoenergetic foods, mostly consumed as a dessert, were used as a meal. One of the foods, cottage cheese, was perceived as a healthy food, whereas the other food, chocolate mousse, was perceived as a nonhealthy food, often avoided by dieters. Subjects perceived chocolate mousse as more full of taste than cottage cheese and scored it higher on the VAS "liking" scale.

Pre- to postmeal changes in appetite profile parameters consisted of a similar decrease in appetite in both NR and NU subjects.

Also ranking of "liking" of the used categories of items (bread, filling, drinks, dessert, sweets, stationery) changed similarly in both subject groups pre- to postmeal. In both conditions (chocolate mousse and cottage cheese) and in both subject groups, test meal consumption induced an increase in relative "liking" for the nonfood alternative, i.e., the stationery category. Consumption of chocolate mousse induced a decrease in relative "liking" for the dessert category, which is the food category the eaten food belongs to. Although ranking of "liking" changed between categories, within each category there was no significant change in ranking of "liking" of the items in both conditions and subject groups.

Despite these similarities between NR and NU subjects concerning appetite and "liking" pre- to postconsumption of chocolate mousse and cottage cheese, there was a large difference in the change in "wanting" pre- to postmeal. NU subjects showed no decrease in "wanting" after eating either chocolate mousse or cottage cheese. In contrast to NU subjects, NR subjects showed a decrease in mean "wanting" for items from any category after test meal consumption. In particular, consumption of chocolate mousse induced a more distinct decrease in "wanting," especially for the bread and filling category, than

consumption of cottage cheese. NU subjects seem to be unaffected by the type of food eaten (i.e., chocolate mousse/cottage cheese), whereas NR subjects seem to be less successful in cognitively controlling their subsequent "wanting" when a healthy perceived food item (cottage cheese) is consumed than when a highly palatable and less healthy perceived food item (chocolate mousse) is consumed, as their decrease in "wanting" was more distinct after chocolate mousse consumption than after cottage cheese consumption. This is in line with Fishbach *et al.* indicating that exposing restrained eaters to tempting and "forbidden" foods may make them more conscious about their weight and eating behavior when planning future food consumption (18). This also implies that dietary restraint subjects are very much focused on unhealthy "forbidden" foods. Therefore, when one follows a diet, it may well be more satisfactory to consume in this case a real dessert thereby decreasing not only "wanting" for dessert but also for many other food items, instead of consuming a "healthy" food that does not limit consumption of other foods.

NR subjects in our study had a relatively low mean disinhibition score and were normal weight, indicating they are successful restraint (19). Testing for possible effects of subject's disinhibition scores (factor 2 TFEQ) by means of ANOVA and regression analyses, showed that disinhibition had no effect on relative "liking" and "wanting" in the chocolate mousse and cottage cheese condition.

A regression analysis indicated that mean "wanting" for items from any category after chocolate mousse consumption, but not after cottage cheese consumption, was inversely related to restraint scores (factor 1 TFEQ). This may again implicate that the type of food consumed has got influence on subsequent "wanting" when being dietary restraint, and the more restraint a subject's attitude is, the stronger the decrease in "wanting."

In summary, in NR subjects as well as in NU subjects, eating a highly liked food item induces a lower ranking of category-specific "liking" vs. placebo. The type of food consumed during a meal has a larger influence on subsequent "wanting" of food in NR eaters than in NU eaters. In those NR eaters, compared with NU eaters, consumption of a food item which is highly liked and perceived as less healthy decreases

“wanting” for food more compared with consumption of a food item which is less liked, neutral, and perceived as healthy.

Thus, for successfully restrained eaters the consumption of a highly rewarding food may result in better control of eating behavior than consumption of a healthy perceived but less rewarding food. Restrained eaters have a similar control over appetite and “liking” as unrestrained eaters, although they use cognitive cues, but they have a stronger control over “wanting” in case of “delicious” foods.

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#### DISCLOSURE

The authors declared no conflict of interest.

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