Available online at www.sciencedirect.com
ScienceDirect
Appetite 49 (2007) 419–428
Appetite
www.elsevier.com/locate/appet

Research Report

Sensory-specific satiety, its crossovers, and subsequent choice of potato chip flavors

Andrea Maier[a,1], Zata Vickers[a,*], J. Jeffrey Inman[b]

[a]Department of Food Science and Nutrition, University of Minnesota, 1334 Eckles Ave, St. Paul, MN 55108, USA
[b]Katz Graduate School of Business, University of Pittsburgh, Pittsburgh, PA 15260, USA

Received 1 September 2006; received in revised form 10 February 2007; accepted 12 February 2007

Abstract

We investigated the influence of liking and flavor intensity on the development of sensory-specific satiety (SSS) to different potato chip flavors, and the influence of these measures, as well as measures of want-to-eat and similarity, on the subsequent choice of a potato chip flavor. In the first study, 35 subjects participated first in a taste test to measure flavor intensity, liking and similarities among six different flavors of potato chips. They then completed six SSS sessions, ending each session by choosing one of the six flavors for additional consumption. SSS varied among the six chip flavors, but was poorly related to either liking or flavor intensity. Subjects chose better-liked flavors, flavors dissimilar to recently consumed flavors, flavors differing in intensity from the recently consumed flavor, flavors that produced less SSS and flavors that produced less change in wanting-to-eat them. In the second study, we used data from a consumption diary panel, and replicated the key finding that when people switch flavors, the similarity to the flavor consumed on the previous occasion decreases the probably of that chip being chosen. Thus switching among flavor choices was driven by liking, the desire for variety and the desire for a product that produced less SSS.

Keywords: Sensory-specific satiety; Variety seeking; Hedonics; Choice behavior; Food choice

Introduction

How many ‘flavor’ choices should a store offer in a product category? What should those choices be? Given limitations of shelf space, which products should be selected to be part of a satisfying category assortment available to consumers? How does one logically determine this assortment? To better answer these questions we must understand the factors that drive flavor choice and switching among flavors within a product category.

One reason consumers switch among products in a category is to satisfy a need for variety (McAlister, 1982; Baumgartner & Steenkamp, 1996; van Trijp, 1995; Van Trijp, Hoyer, & Inman, 1996). Variety-seeking behavior has been defined as the tendency for a person to switch away from an item consumed during the last occasion (van Trijp, 1995; Ratner, Kahn, & Kahneman, 1999). When offered a variety of food products, people often switch among them (Van Trijp et al., 1996; Inman, 2001). Variety-seeking behavior has been hypothesized to come from both implicit and explicit processes (McAlister, 1982; Baumgartner & Steenkamp, 1996; van Trijp, 1995; Van Trijp et al., 1996). The implicit process is hypothesized to include internal mechanisms such as attribute satiation (McAlister, 1979; McAlister, 1982), curiosity about non-chosen alternatives (Raju, 1980), or boredom with the previously chosen product (Loewenstein, 1994). In contrast, the explicit process deals with external factors such as purchase strategy, display format (Simonson & Winer, 1992), price changes (Gupta, 1988), and changes in the social or situational constraints (Menon & Kahn, 1995). Relatively less is understood about the implicit factors affecting variety seeking, as their identification and measurement

*Corresponding author.
E-mail address: zvickers@umn.edu (Z. Vickers).
[1]Current address: Nestlé Research Center, P.O. Box. 44, CH-1000 Lausanne 26, Switzerland.

0195-6663/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.appet.2007.02.006

depend on experimental protocols in which people actually consume the products and thus experience attribute satiation, boredom, etc.

The idea of an optimum level of stimulation has served as a basis for understanding variety-seeking behavior (Zuckerman, 1979; McAlister, 1982; van Trijp, 1995). When the level of stimulation falls below a specific point, individuals respond by seeking additional stimulation, often by adding variety or novel stimuli to their life. In contrast, if the level of stimulation is above the optimum, then the individual tends to avoid novel stimuli or variety (Berlyne, 1960; Berlyne, 1966). The level of stimulation that a consumer derives from using a product in a category depends in part on the difference between the currently chosen product and the previously consumed one. By selecting alternatives that have not been chosen recently, individuals may increase their level of stimulation, as well as prevent boredom and satiation, two negative psychological consequences of repetition (Berlyne, 1970; Inman, 2001). Switches between two highly similar alternatives (e.g., two similar flavors) may not yield the desired level of new stimulation.

The level of stimulation that a consumer derives from a specific flavor option is also related to the overall intensity of the flavor. Although little research is available on this topic, people appear to tire of intensely flavored products more rapidly than they tire of bland products (Drewnowski, Grinker, & Hirsch, 1982; Vickers, 1999). Few other sensory-specific satiety (SSS) studies have been designed to measure the effect of flavor intensity on the extent of SSS. Those that allow such a comparison generally show no effect of odor or flavor intensity on SSS (Vickers & Holton, 1998; Rolls & Rolls, 1997; Guinard, Caussin, Campo Arribas, & Meier, 2002). One of the objectives of our research was to examine the influence of flavor intensity on SSS.

Inman (2001) observed that within a product category, consumers sought variety in the sensory attributes of products (e.g., flavor) more than in the non-sensory attributes. He proposed SSS as an implicit factor that may drive variety seeking among flavors within a product category. SSS is the temporary drop in liking of a food produced by eating that food, whereas uneaten foods remain pleasant when tested under the same conditions (Rolls, 1986). Thus, Inman suggested that people tiring of, or temporarily growing to dislike, specific flavors causes some of the observed switching among products.

Liking is one of the major drivers of consumers' food choices (Rozin & Vollmecke, 1986; Tuorila & Pangborn, 1988; Lähteenmäki & van Trijp, 1995; Tuorila, Kramer, & Engell, 2001; Hirsch & Kramer, 2001). Lähteenmäki and van Trijp (1995) observed that well-liked filled sandwiches were chosen more often than were the less-liked options. In a series of studies of military rations, Hirsch and Kramer (2002) measured the relationship between differences in hedonic ratings of pairs of food items and choice between the food items. They found that initially better-liked foods were more frequently chosen.

Some of our participants in previous SSS studies have told us they still liked the food after eating it; they were just tired of eating it and did not want to eat more. When we only allowed them to give one response (liking), they may have 'dumped' their wanting into those liking ratings. Evidence from experiments with animals and growing evidence from human studies support a differentiation of liking from wanting (Berridge, 1996; Berridge & Robinson, 1998; Mela, 2006). Berridge (1996, 2004) has provided considerable evidence that liking and wanting are separate neural processes even though they are often highly correlated. Blundell and Rogers (1991), Mela (2001) and Mela and Rogers (1998) have suggested that eating a food in the typical SSS laboratory protocol may primarily influence the wanting of the food as opposed to the liking of the food. One of our objectives for this research was to examine both the liking and want-to-eat ratings of foods in a SSS protocol.

The overall goal of our research was to measure the SSS of different potato chip flavors and relate measurements from this protocol to taste test measurements of these potato chips and to the choice of these potato chips in both a laboratory and a field study. First, we hypothesized that flavors that were perceived as higher in intensity would generate greater SSS and greater changes in want-to-eat. Second, we tested the impact of SSS for the eaten chip on the change in liking of other flavors of potato chips and hypothesized that this 'SSS crossover' would be related to the similarity of the other flavors to the eaten chip. Third, we tested the assertion that consumption in a SSS protocol generates greater changes in wanting the food than liking of the food. Fourth, we examined how the following influenced the subsequent choice of a potato chip flavor: difference between the flavor intensity of the chosen chip and the eaten chip, liking of the chip, the similarity of the chip to the eaten chip, and SSS and the change in want-to-eat of the chips. We hypothesized that people would be more likely to choose better-liked flavors, less intense flavors, flavors that produced less SSS, and flavors that were more dissimilar to the just-eaten potato chip. Finally, we compared our laboratory choice data with data taken from a large diary study that used the same six potato chip flavors. The greater external validity of the diary study enabled us to test the generalizability of our findings regarding the frequency of the choices and the influence of sensory differences among the chips on subsequent choices. In conjunction, the two studies yield more confidence in our results than either of them in isolation.

Study 1

Material and methods

Subjects: One hundred students and staff from the University of Minnesota (56 females and 44 males; mean age, 31, range 20–56) participated in the taste test portion of the study. Of these, 35 participated in the SSS and choice tests. Those 35 subjects (19 females and 16 males, mean age 33 years, range 20–55 years) reported that they liked all of the foods used in the study, and also indicated that they could eat at least five of the six potato chip flavors as an afternoon snack. We paid the subjects for their participation. The University of Minnesota Institutional Review Board approved this research.

Foods: Taste test. We served about 10 g of six different flavors of potato chips (Frito Lay Cheese®, Frito Lay Ruffles®, Frito Lay Sour Cream & Onion®, Frito Lay Barbeque®, Frito Lay Ranch Santa Fe® and Frito Lay Classic®) in 120 ml plastic soufflé cups coded with 3-digit numbers.

Foods: SSS and choice test. We used the same brands and flavors of chips in this part of the study as in the taste test. To induce SSS we served 80 g (1799 KJ or 430 kcal) of a single potato chip flavor (the test chip) in a white paper bag. In addition to each test chip, small pieces of the following 12 different foods, chosen because they varied in sensory characteristics, were included in the rating set: bread (English Muffin® Toasting Bread), granola bar (Sunbelt®), carrot (Nature's Finest Baby Carrots®), orange juice (Minute Maid Premium Original®), M&Ms® (Plain), M&Ms® (Crispy), and the six different flavors of potato chips (cheese, Ruffles, sour cream & onion, barbeque, ranch Santa Fe and Classic). We served the rating set foods in 2-g (approximate) portions in 30 ml plastic soufflé cups coded with 3-digit numbers.

Experimental procedure

Taste test: During the taste test session each subject received a single tray with all six flavors of potato chips. They first rated each chip for overall liking and flavor intensity, both on 9-point category scales labeled only at the ends (dislike extremely—like extremely; very weak flavor—very strong flavor). Finally, they rated the perceived similarity between all possible pairs of potato chip samples using a 9-point category scale labeled 'extremely dissimilar' at the left end and 'extremely similar' at the right end.

Sensory-specific satiety test: The 35 subjects participating in the subsequent SSS study attended six different test sessions, one session for each of the six potato chip flavors. The order of the tests was randomized across subjects. Upon arrival, they rated their hunger, how full they felt, and 'how much food (potato chips) do you think you could eat right now?' on 120 mm line scales labeled only at the ends (not hungry at all—extremely hungry; not full at all—extremely full; nothing at all—a large amount). In addition, they recorded the amounts of any foods and beverages they had consumed for breakfast and lunch prior to the session. (These data are not reported here.) Subjects then tasted each of the 12 rating set foods and rated them for liking and for 'how much do you want to eat this right now', both on 15-point scales labeled only at the ends (dislike extremely = 1, like extremely = 15; not at all = 1, very much = 15). The rating set foods were always evaluated in the order listed in the product section. Following the evaluation of the rating set foods, subjects were given an 80 g serving of the test chip and instructed to eat the entire amount. Immediately after consuming the test chip, subjects repeated their hunger indices ratings (hunger, fullness and amount), and then re-tasted and re-rated another set of the 12 food items.

Choice test

Immediately after re-tasting and re-rating the foods, the subjects were given an opportunity to choose any of the potato chip flavors to eat. These instructions were presented in two ways: (1) they were stated verbally to the subject by the experimenter and (2) they were presented in written form, on a sheet in front of the subject. ('In case you did not get enough to eat we have more chips available. Help yourself to one of these bowls.') At this time we presented the subjects with a tray containing six bowls of the chips. Subjects could eat no more than the offered serving size (about 20 g) and could not take home any of the potato chips. If subjects said they were unable to eat any more potato chips (often the case) we instructed them to select one flavor of their choice. We recorded the choice and the weight of any potato chips consumed (original weight minus residual weight).

Data analyses

Taste test

We analyzed the data of only the 35 subjects who had participated in both the taste test and the SSS test using SAS (version 8.2) (SAS Institute, 2001). Statistical significance was always set at 0.05. We used analyses of variance (Proc ANOVA) to determine whether the six potato chip flavors differed in liking and flavor intensity followed by a Bonferroni multiple comparison procedure to determine which pairs of chips differed from each other. The dependent variables for the ANOVA were the ratings; predictors were judge and potato chip flavor.

We used ANOVA to determine whether ratings of males differed from ratings of females and whether ratings of younger subjects (under 30 years of age) differed from ratings of older subjects (30 years or older). The dependent variables in these analyses were the ratings; predictors were: judge nested in gender, gender, product, and product*gender (or judge nested in age group, age group, product, and age group*product).

We analyzed the flavor similarity ratings between all pairs of the six chip flavors by multidimensional scaling (Proc MDS), which located the six flavors on a two-dimensional map with the property that the distance between points in the space co-varied with their dissimilarity.

Sensory-specific satiety test

Hunger indices: Ratings for the subjects' level of hunger, fullness and amount they thought they could eat were measured in millimeters from the left end of the line scale. We calculated changes in ratings by subtracting the subject's pre-consumption rating from the rating after consumption of a test chip. We used ANOVA to determine whether initial hunger indices (hunger/fullness/amount ratings) or changes in these indices differed significantly among the potato chip flavors, and we used Bonferroni multiple comparison tests to determine differences among specific chip pairs.

Change in liking and change in want-to-eat ratings. These analyses required the creation of four new variables: sensory-specific satiety (SSS), SSS crossovers, change in want-to-eat (ΔWTE), and change in want-to-eat crossovers (ΔWTE crossovers).

SSS: Sensory-specific satiety equaled the change in liking of the eaten test chip minus the average change in liking for the non-chip foods in the rating set (Rolls, 1986).

SSS Crossover: Five additional variables, called SSS crossovers were created for each judge and each test chip. We computed the SSS crossover values by subtracting the average change in liking for the non-chip foods from the change in liking for each of the five uneaten chips.

ΔWTE: We computed the want-to-eat change (ΔWTE) for each judge by subtracting the mean change in want-to-eat ratings for the non-chip foods from the mean change in want-to-eat ratings for the eaten chip. ΔWTE is the same as SSS, except computed on the want-to-eat ratings instead of the liking ratings.

ΔWTE Crossover: Five want-to-eat crossovers (ΔWTE crossover) were created for each judge and each test chip by subtracting the average change in want-to-eat ratings for the non-chip foods from the change in want-to-eat ratings for each uneaten chip. This measure is the same as SSS crossover, except computed on the want-to-eat ratings instead of the liking ratings.

We used separate ANOVA for each test chip to determine whether SSS and SSS crossovers differed among chip flavors. SSS and SSS crossovers served as dependent variables; chip flavor and judge were predictors. We used a similar procedure to determine whether ΔWTE and ΔWTE crossovers differed among chip flavors. We then used ANOVA to determine whether the six test chips generated different amounts of SSS or ΔWTE. SSS (or ΔWTE) served as the dependent variable; judge and chip flavor were predictors. We used Bonferroni means comparisons to determine which pairs of the individual test chips differed in SSS or ΔWTE. We also used ANOVA to determine whether gender or age affected SSS or ΔWTE. SSS or ΔWTE served as the dependent variable; judge nested in age (gender), age (gender), chip flavor and chip flavor∗age (gender) served as predictors.

Flavor similarity vs. difference between SSS and SSS crossovers. We used linear regression to compare the absolute differences between the SSS crossover values for each pair of chip flavors to the similarity measurements (from the taste test) between each pair of chips. Each pair of chip flavors generated two SSS crossovers (one when the first member of the pair was the test chip and the other when the second member of the pair was the test chip), yielding 30 pair combinations. The mean of these two crossover values for each judge was used in the analysis.

Relation of flavor intensity, liking, purchase, and preference on SSS. We used linear regression to determine whether SSS induced by the test chip could be related to taste test ratings of the test chip for flavor intensity and overall liking.

Choice

We used multinomial discrete choice analysis (Proc MDC, SAS 8.2) to determine the effect of the following variables on probability of choice:

- Difference in flavor intensity between the chip and the eaten chip. (1 = same level of intensity; 0 = different level of intensity). We considered Classic and Ruffles to be one level of intensity and the other four chip flavors to be a second level of intensity.
- Similarity in flavor between the chip and the eaten flavor.
- SSS or SSS crossover of the chip.
- ΔWTE of the chip.
- Liking of the chip (from the initial liking rating at that SSS test session).
- Whether the chip was the test chip.

These analyses necessitated choosing one of the six flavors as a reference, which was omitted from the equation. Thus we included five dummy variables representing the five test chip flavors (excluding Ranch). We omitted the ranch-flavored chip from the choice model because it was the least frequently chosen and the least-liked sample. Choice was the dependent variable, and the variables listed above were predictors. We began with the base model including only the dummy variables and added other variables in a step-wise manner to improve the fit of the model (greatest log likelihood).

Results

Taste test

Panelists rated the ranch-flavored chip significantly lower in liking compared to the Classic and the sour cream-flavored chips [$F\ (5,170) = 3.05$, $p < 0.01$] (Table 1). They rated the flavor of Classic and Ruffles significantly less intense than all the other chips [$F\ (5,170) = 25.0$, $p < 0.001$].

Younger respondents (under 30 years of age) did not differ from older respondents on any taste test rating. Generally, women rated the chip flavors as tasting more intense than did men [$F\ (1,154) = 4.08$, $p < 0.04$]. Females

Table 1
Mean ($n = 35$) taste test ratings of overall liking for the six chip flavors

Chip flavor	Liking*
Cheese	$5.8^{a,b}$
Ruffles	$6.4^{a,b}$
Sour cream	6.6^{a}
BBQ	$6.4^{a,b}$
Ranch	5.3^{b}
Classic	6.6^{a}

Numbers within a column having letter superscripts in common do not differ significantly ($p > 0.05$).
*Mean ratings from a 9-box scale labeled at the left end 'dislike extremely' and at the right end 'like extremely'. Larger numbers indicate greater liking.

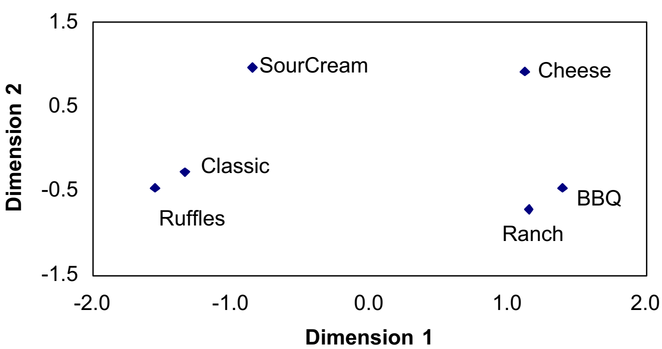

Fig. 1. Multidimensional scaling map of flavor similarity. The horizontal and vertical axes are the first two dimensions determined by the multidimensional scaling procedure. The farther apart a pair of potato chip samples is on the map, the more dissimilar they are.

rated Ruffles, sour cream and Classic chips higher on liking. Males rated ranch and BBQ chips higher on liking [$F\,(5,154) = 2.38$, $p < 0.04$].

Panelists considered Ruffles and Classic similar. They considered Cheese quite dissimilar to both Classic and Ruffles as well as to BBQ and Ranch (Fig. 1).

Sensory specific satiety test

None of the initial hunger indices (hunger, fullness and amount of potato chips subjects thought they were able to eat) differed among the potato chip flavors. No significant differences among the test chips emerged with respect to the changes in rated 'hunger' and 'amount they were able to eat'. Subjects rated their fullness after eating the Ruffles chip greater than their fullness after eating the Ranch chip [$F\,(5,170) = 2.75$, $p < 0.02$]).

Generally we observed sensory-specific satiety (the specific chip flavor that had been eaten as the test food dropped more in liking than did the uneaten chips in the rating set) although this was not always statistically significant (Table 2). The only chip that did not show this pattern was Classic. Cheese generated the highest SSS score, followed by Ruffles, BBQ, Sour cream, Ranch and Classic (Table 2). Some subjects exhibited more SSS than did others [$F\,(32,154) = 2.58$, $p < 0.001$]. Women and men

Table 2
Sensory-specific satiety (SSS) and SSS crossovers† for each chip flavor

Test chip	Rating set chip						*F* value‡	*P*<
	Cheese	Ruffles	Sour cream	BBQ	Ranch	Classic		
Cheese^{C}	$-\mathbf{3.8}^{\mathbf{b}}$	-1.5^{a}	-0.4^{a}	-0.9^{a}	-1.3^{a}	-1.3^{a}	9.8	0.0001
Ruffles^{BC}	-1.1^{a}	$-\mathbf{3.3}^{\mathbf{b}}$	-1.4^{a}	-0.6^{a}	-1.0^{a}	-1.6^{a}	8.5	0.0001
Sour cream^{ABC}	$-1.3^{a,b}$	-1.1^{a}	$-\mathbf{2.5}^{\mathbf{b}}$	$-1.7^{a,b}$	-1.0^{a}	-0.5^{a}	3.3	0.0075
BBQ^{BC}	$-1.5^{a,b}$	-0.8^{a}	-0.3^{a}	$-\mathbf{2.7}^{\mathbf{b}}$	-1.1^{a}	$-1.3^{a,b}$	5.9	0.0001
Ranch^{AB}	$-1.4^{a,b}$	$-1.1^{a,b}$	$-1.1^{a,b}$	$-1.1^{a,b}$	$-\mathbf{2.1}^{\mathbf{b}}$	-0.4^{a}	2.6	0.03
Classic^{A}	-0.9^{a}	-1.3^{a}	-1.0^{a}	-0.7^{a}	0^{a}	$-\mathbf{1.2}^{\mathbf{a}}$	1.6	0.17

Bolded values show SSS values, and unbolded rating set chip cells show SSS crossover values.
Numbers within a row having lower case letter superscripts in common do not differ significantly ($p > 0.05$).
Chips within the test chip column having upper case letter superscripts in common do not differ significantly in sensory-specific satiety ($p > 0.05$).
†Computed for each judge and test chip by subtracting the average change in liking for the non-chip foods from the change in liking for each of the five uneaten chips. Liking ratings were made on 15-box scales labeled at the left 'dislike extremely' = 1 and at the right end 'like extremely' = 15.
‡*F*-value from the ANOVA comparing the SSS and SSS crossover ratings for each test chip. All tests have 5, 170 degrees of freedom.

did not differ in the extent of SSS produced among the six chip flavors [$F\,(1,154) = 1.86$ $p > 0.18$]. Younger (under 30 years old) subjects and older subjects did not differ in the extent of SSS among the six chip flavors [$F\,(1,154) = 1.37$, $p > 0.24$].

No significant differences between ΔWTE and ΔWTE crossovers occurred for any of the six potato chip flavors (Table 3), and the magnitude of ΔWTE did not differ across the six chip flavors. Some subjects exhibited more ΔWTE than did others [$F\,(32,154) = 2.12$, $p < 0.001$]. Women and men did not differ in the extent of ΔWTE produced among the six chip flavors [$F\,(1,154) = 0.72$, $p > 0.40$], and we observed no significant differences in ΔWTE between younger and older subjects [$F\,(1,154) = 0.09$, $p > 0.76$].

In contrast to our original hypothesis that more similar products would show greater crossover SSS, we observed no relation between the rated flavor similarity of each pair of chips and the absolute differences between their SSS crossover values ($t = -1.55$, $p > 0.12$).

Want-to-eat ratings usually decreased significantly more than liking ratings as a consequence of completing the SSS protocol, with the exception of the eaten chips. In Fig. 2 almost all points (all of the non-chip foods and the uneaten chips) fall below a 1:1 diagonal line—indicating that the decreases in WTE ratings were greater than the decreases in liking ratings. However, the liking ratings of the *eaten* chips decreased more relative to the liking ratings of the uneaten chips, whereas the WTE ratings of these eaten chips did not decrease more than the WTE ratings of the non-eaten chips.

Table 3
Mean ($n = 35$) ΔWTE† and ΔWTE crossovers‡ for each chip flavor

Test chip	Rating set chip						F value*	P<
	Cheese	Ruffles	Sour cream	BBQ	Ranch	Classic		
Cheese	**-2.6^{a}**	-2.5^{a}	-1.6^{a}	-1.8^{a}	-1.6^{a}	-1.8^{a}	1.0	0.44
Ruffles	-1.7^{a}	**-1.9^{a}**	-1.6^{a}	-1.2^{a}	-1.0^{a}	-1.6^{a}	0.6	0.70
Sour cream	-2.5^{a}	-2.3^{a}	**-2.1^{a}**	-2.2^{a}	-1.6^{a}	-1.5^{a}	1.0	0.41
BBQ	-2.4^{a}	-2.0^{a}	-1.7^{a}	**-2.1^{a}**	-2.5^{a}	-2.4^{a}	0.7	0.60
Ranch	-2.4^{a}	-2.7^{a}	-2.0^{a}	-2.0^{a}	**-2.2^{a}**	-1.4^{a}	1.1	0.37
Classic	-2.3^{a}	-2.5^{a}	-1.4^{a}	-1.4^{a}	-0.8^{a}	**-1.8^{a}**	1.8	0.11

Bolded values show ΔWTE values; unbolded values for rating set chips show ΔWTE crossover values.
Numbers within a row having letter superscripts in common do not differ significantly ($p > 0.05$).
†ΔWTE: We computed the want-to-eat change (ΔWTE) for each judge by subtracting the mean change in want-to-eat ratings for the non-chip foods from the mean change in want-to-eat ratings for the eaten chip. Want-to-eat ratings were made on a 15-box scale labeled at the left 'not at all' = 1 and at the right end 'very much' = 15.
‡ΔWTE crossovers: We computed ΔWTE crossovers for each judge and test chip by subtracting the average change in want-to-eat for the non-chip foods from the change in want-to-eat for each of the five uneaten chips.
*F-value from the ANOVA comparing the ΔWTE and ΔWTE crossover ratings for each test chip. All have 5, 170 degrees of freedom.

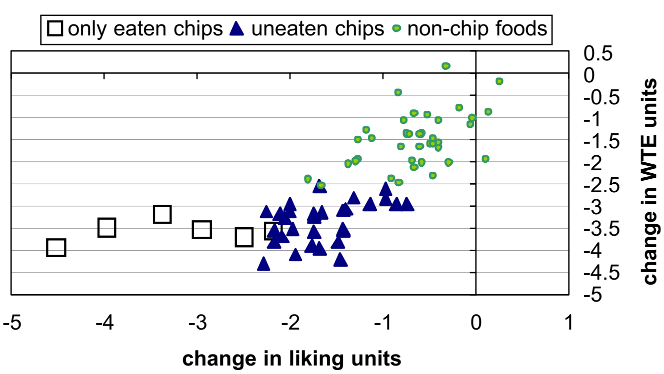

Fig. 2. Changes in liking vs. changes in want-to-eat (WTE) for all foods in the sensory specific satiety test sessions. Generally the changes in WTE are greater than the changes in liking (most all points fall below a 1:1 diagonal line). The exceptions are the points for the eaten chips, which show about the same change in WTE as do the uneaten chips, but a relatively greater change in liking.

Choice

When asked at the end of the test session to choose a flavor, on 93% of the occasions participants chose a different flavor of chip than the one they had just eaten as a test chip (Table 4). When subjects consumed test chips other than Ruffles or Classic, they most frequently chose Classic chips. When subjects consumed Ruffles or Classic chips, they most frequently chose BBQ chips (Table 4).

The following features of a chip increased the probability of its being chosen: greater liking of that chip, smaller extent of sensory specific satiety for that chip, and greater dissimilarity of that chip to the chip just eaten (Table 5).

Table 4
Number of participants (out of 35) choosing each chip flavor after consuming a specific test chip

Test chip	Chosen chip flavor					
	Cheese	Ruffles	Sour cream	BBQ	Ranch	Classic
Cheese	**1**	4	5	6	1	18
Ruffles	1	**2**	7	21	0	4
Sour cream	3	6	**1**	8	0	17
BBQ	1	8	1	**5**	2	18
Ranch	3	6	3	4	**0**	19
Classic	5	4	5	14	1	**6**

Bolded and underlined values are the number of people choosing a chip flavor immediately after having consumed it as a test chip.

Table 5
Maximum likelihood estimates of the coefficients relating flavor choice to liking, intensity difference, whether the test chip was chosen, similarity to the test chip, ΔWTE, and SSS

Predictors	Coefficient	t-Value	P<	% Increase in probability[g]
Cheese dummy	1.19	2.1	0.04	
Ruffles dummy	1.93	3.6	0.0004	
Sour cream dummy	1.72	3.1	0.002	
BBQ dummy	2.66	5.1	0.0001	
Classic dummy	3.20	6.1	0.0001	
Liking[a]	0.35	6.3	0.0001	42
Intensity difference[b]	0.074	1.1	0.26	8
Test chip[c]	−0.181	−0.5	0.60	
Similarity to test chip[d]	−0.126	−2.8	0.005	−13
ΔWTE[e]	0.056	1.2	0.24	6
SSS[f]	0.113	2.	0.04	12
Log likelihood	−271.63			
Likelihood ratio	209.26			

The dependent variable was choice. Data includes all 35 panelists and all 6 sensory-specific satiety sessions.
[a]Liking of the chip (from the initial liking rating at that SSS test session).
[b]Difference in flavor intensity between the chip and the eaten chip. (1 = same level of intensity; 0 = different level of intensity).
[c]Effect of having been the test chip.
[d]Similarity between the chip and the eaten chip flavors.
[e]ΔWTE of the chip.
[f]SSS of the chip.
[g]The % change in probability of a chip being chosen produced by a 1-unit change in the predictor.

A chip was also more likely to be chosen the greater the intensity difference between it and the eaten chip, although in our final best model (Table 5) the size and significance of this effect was overridden by the size of the dissimilarity between the chips. Similarly, a chip was more likely to be chosen the smaller the change in want-to-eat for that chip, although in our final best model the size and significance of this effect was overridden by the size of the SSS of that chip. These observations provide strong support for our fourth hypothesis that people would choose better-liked flavors, flavors that produce less SSS and less want-to-eat, and flavors more dissimilar to the just-eaten potato chip.

The parameter estimate for SSS (0.11) indicates that for every one-point increase in the SSS value (remember that increases in the SSS value represent less SSS), the likelihood of that chip being chosen increased by about 12%. Similarity to the preload exerted a significant negative effect on choice (-0.13, $p<0.001$), indicating that for every one-point increase in perceived similarity to the preload, the likelihood of that chip being chosen decreased by about 15%. These and other percent changes in the probability of choosing a chip flavor are shown in Table 5. Importantly, the fit of the final best model was improved over the model containing only the dummy variables (likelihood ratio test ($\chi^2(2) = 41.0$, $p<0.001$).

Discussion

We had expected people to tire more quickly and thus show more SSS for the more intense flavors. Because the Ruffles chip appeared to have higher SSS due to its texture, this texture effect would have been confounded with our other differences in flavor intensity. When we removed Ruffles from the data set and recalculated the regression relating liking and flavor intensity to SSS, increases in flavor intensity significantly increased the extent of SSS (coefficient for intensity $= -0.27$; $t = -1.9$; $p<0.05$). Thus, our first hypothesis that higher flavor intensity appears to increase SSS is supported. Further testing that manipulates flavor intensity independently of other sensory attributes will be necessary to clearly show this.

We were surprised that the SSS crossovers were uncorrelated with measures of similarity between chip flavors because many others (e.g. Johnson & Vickers, 1993; Rolls, Hetherington, & Burley, 1988; Rolls & Rolls, 1997) have shown that foods with flavors similar to the eaten food tend to decrease in liking during the SSS test protocol. Our failure to observe this relationship may be because all our chip flavors could be considered similar to the eaten chip. All were similar in flavor (salty, savory), texture (crisp, oily), and use. Within this limited range of sensory attributes, similarity differences may not be large enough to influence SSS crossovers. Thus our second hypothesis that SSS crossovers would be related to similarity between the eaten chip and the other chip flavors was not supported.

Our observation that the liking (but not the wanting) of the eaten chip decreased more than that of the uneaten potato chips does not support our third hypothesis and the hypothesis suggested by Blundell and Rogers (1991), Mela (2001) and Mela and Rogers (1998) that eating a food in the typical SSS laboratory protocol would influence the wanting of the food more than the liking of the food. Perhaps our strategy for collecting subjects' ratings of liking and wanting did not produce valid measurements relevant for testing this hypothesis. Finlayson, King, and Blundell (2006) noted that people's ratings of wanting would reflect only the extent to which they were consciously aware of wanting. Their conscious perception of wanting may not accurately reflect the incentive salience that is key to the Berridge model of wanting (Berridge, 1996). So even though our data appear to refute the hypothesis based on Berridge's model, our methodology for measuring both liking and wanting may not have provided a fair test of that hypothesis. Our subjects' choosing of a chip flavor at the end of each test session may have provided a more valid indicator of *wanting* according to Berridge's model, because the act of reaching out to take or to point to a particular chip flavor may have relied more on the unconscious incentive motivations for that product. That our liking ratings predicted this choice better than did the want-to-eat ratings (Table 5) may provide additional evidence for our want-to-eat ratings not being valid measures of Berridge's *wanting*.

Classic and Ruffles chips were very similar in flavor, having no added flavors other than the oils and salt, thus the difference between them in texture likely explains why Ruffles had more SSS than Classic chips. (SSS for Ruffles was -3.3 and for Classic was -1.2.) The thicker and corrugated shape of the Ruffles chips is much stronger and thus harder to break or crush. Guinard and Brun (1998) observed that eating a baguette sandwich produced a larger decrease in the pleasantness of the texture than did eating a sandwich on white bread. (The baguette sandwich was harder than the white bread sandwich.) However, they did not observe a similar difference between an apple (hard) and applesauce (soft), possibly because that latter comparison was confounded with the subjects eating much more applesauce than apples. Our comparison of the SSS for Ruffles and Classic provides evidence that foods with harder textures and a more distinguished shape (i.e., wavy) produce more SSS than less hard and smoother foods.

The relatively high frequency with which the BBQ chip was selected may be due to its sweetness, an attribute we did not measure. The BBQ chip had added sugar (7% compared to the other chip flavors which had less than 3.5% or no sugar added). Its choice may have been due to cultural desires to finish a meal with something tasting sweet (Weingarten & Elston, 1991; Conner, Haddon, Pickering, & Booth, 1988; Conner & Booth, 1988), or may be due simply to our innate sweet preference (Pudel, 1980). Because we failed to measure the key attribute(s) driving the choice of the BBQ chip, our multinomial discrete choice model is incomplete.

We chose the mid afternoon time for the test session to ensure that subjects would be at comparable levels of hunger and willingness to eat a snack. However, due to the large portions of the test chip served, some subjects told us they eventually stopped eating their typical breakfast and/or lunch prior to the test session. We examined the initial hunger indices over the course of the study (Fig. 3) to determine whether the hunger was increasing over time,

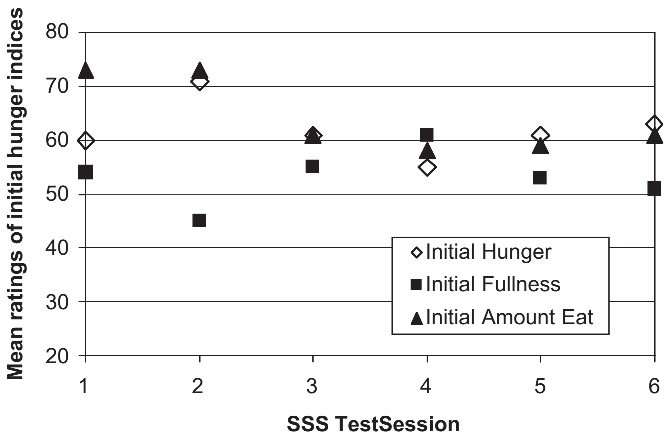

Fig. 3. Mean ratings ($n = 35$) for initial hunger, fullness and "how much food (potato chips) do you think you could eat right now?" for all six sensory-specific satiety (SSS) test sessions. Subjects rated the 3 indices on 120 mm line scales labeled only at the ends (not hungry at all—extremely hungry; not full at all—extremely full; nothing at all—a large amount).

but with the exception of ratings at the second test session, the hunger indices were fairly stable.

Study 2

Introduction

The objective of study 2 was to compare the results of a diary-based field study that measured repeated consumption of these same six potato chip flavors with our laboratory study. Particularly in terms of external validity, finding that people switch to dissimilar flavors in a diary panel makes a convincing argument as to the generalizability of our findings in the controlled laboratory study. For example, in study 1, subjects made their choice immediately following the preload. In contrast, in study 2, a considerable amount of time might pass between successive eating occasions, allowing for SSS to dissipate. If people switch to a dissimilar flavor to that previously consumed, this suggests that the SSS effects are long lasting.

Methods

A national marketing research supplier, Cunningham Sensory Services, collected the data for this study, which is more completely described in Inman (2001). Subjects completed a diary of their consumption occasions for 10 snack food categories over a 6-week period. We focused our analysis on only the potato chip consumption data. Participants in the study were 850 individuals from 260 households in a medium-sized Midwestern city and a medium-sized Southern city. The female head of household was responsible for ensuring that the data for each week were entered for each household member.

The diary was organized as a grid with each row representing a consumption event. Several measures were taken for each consumption occasion. The time of day was recorded first, along with whether or not the consumption occurred at a particular meal (e.g., breakfast). After entering a code for the product category consumed, respondents were asked to refer to the product label and record the brand name, flavor, and size of the bag/package. The amount consumed was logged as either the number of pieces or portion of the package. Finally, the other foods that were consumed along with the focal category were recorded, followed by a code describing the activity in which the respondent was engaged during the consumption event. For our current purposes, only the individual, category, brand, and flavor are of interest. The final potato chip database consisted of almost 5404 eating occasions. (See Inman, 2001 for a listing of eating occasions of all 10 product categories.)

Our prediction was that similarity to the chip flavor consumed on the last occasion will have a negative effect on the flavor's probability of being consumed on the present occasion, ceteris paribus. To test this prediction, we again used multinomial discrete choice analysis (Proc MDC, SAS 8.2), with choice as the dependent variable and lagged flavor (flavor consumed on the previous occasion) and similarity to the previous flavor as the predictors. The similarity measures were the mean values from the taste test in study 1. The key difference between this analysis and the choice analysis presented earlier is that we did not have either liking measures or SSS measures at each occasion. The combined effect of these constructs is captured by the coefficient for lagged flavor. In order to test whether similarity to the previous flavor impacts choice, we first estimated the model with only flavor intercepts and lagged flavor, using classic as the baseline flavor.

Results

The ordering of the flavor intercepts matches that from study 1, supporting our hypothesis of external validity. Ranch was the least-chosen flavor, followed by Cheddar, sour cream, Ruffles, BBQ, and classic (Table 6). The lagged flavor coefficient is positive and significant (2.90), indicating that the previously consumed flavor is likely to be consumed again. When similarity to the lagged flavor was added, its coefficient was negative and significant (−0.29), indicating that when the eaters do switch, they tend to switch to a dissimilar flavor. The fit of the model is improved with the addition of these two terms, as indicated by the likelihood ratio test ($\chi^2 = 38.8$, $p < 0.001$).

Discussion

Subjects in the field study most often selected the same chip flavor they had eaten previously in contrast to the subjects in the laboratory study who rarely selected the same flavor they had just eaten. We attribute this difference to the fact that subjects in the field study had previously selected a chip based on their liking, whereas in the laboratory study, subjects ate assigned chip flavors.

Table 6
Maximum likelihood estimate of the coefficients relating flavor choice to lagged flavor and similarity to that flavor

Predictors in the MNL Model	Model 1	Model 2
	Flavor intercepts and lagged flavor	Same as model 1 plus similarity to previous flavor
Cheese dummy	−3.64**	−4.37**
Ruffles dummy	−2.87**	−3.19**
Sour cream dummy	−3.00**	−3.51**
BBQ dummy	−2.58**	−3.28**
Ranch dummy	−4.54**	−5.23**
Flavor_{t-1}	2.90**	3.47**
Similarity to flavor_{t-1}		−0.29**
Log likelihood	−3857.9	−3840.0
Likelihood ratio test		35.8**

The dependent variable is choice; the independent variables are the previously consumed flavor dummy and similarity to that flavor.
**$p<0.01$.

Because liking is such a strong predictor of choice, we assume people in the field study selected the chip flavor(s) they liked best and did so repeatedly.

Both laboratory and field study participants chose dissimilar flavors when they switched flavors. This is impressive, since the time between consumption and the next choice occasion was much greater in the field than in our laboratory study. These findings support Inman's (2001) findings that SSS effects on variety seeking tend to be relatively long lasting. We extend those results to show that similar flavors to the previously consumed flavor are affected as well. The comparison of studies 1 and 2 support our hypothesis that the laboratory choice tests were valid predictors of real world choices when people switched among products.

Conclusions

The relative frequency with which people selected different potato chip flavors was similar in both the laboratory and the field study, providing external validity for the choice results from the laboratory study. In both studies people switched towards products that were dissimilar to the flavor they had most recently eaten. As people in the laboratory study switched among flavor choices, they were likely to choose better liked flavors, flavors dissimilar to recently consumed flavors, and flavors that produced less sensory-specific satiety (SSS). The hypothesis that SSS crossovers would be related to the similarity of the other flavors to the eaten chip was not supported.

Acknowledgment

This research was partially supported by a Grant to Vickers and Inman from the Retail Food Industry Center at the University of Minnesota. Partial support was also provided by the Minnesota Agricultural Experiment Station. We thank the Frito-Lay company for donating the potato chips.

References

Baumgartner, H., & Steenkamp, J. E. M. (1996). Exploratory consumer buying behavior: Conceptualization and measurement. *International Journal of Research in Marketing*, *13*, 121–137.

Berlyne, D. E. (1960). *Conflict, arousal, and curiosity*. New York: McGraw-Hill (p. 350).

Berlyne, D. E. (1966). Curiosity and exploration. *Science*, *153*, 25–33.

Berlyne, D. E. (1970). Novelty, complexity and hedonic value. *Perception and Psychophysics*, *8*, 279–286.

Berridge, K. C. (1996). Food reward: Brain substrates of wanting and liking. *Neuroscience & Biobehavioral Reviews*, *20*, 1–25.

Berridge, K. C., & Robinson, T. E. (1998). What is the role of dopamine in reward: Hedonic impact, reward learning, or incentive salience? *Brain Research Review*, *28*, 309–369.

Berridge, K. C. (2004). Motivation concepts in behavioral neuroscience. *Physiology and Behavior*, *81*, 179–209.

Blundell, J. E., & Rogers, P. J. (1991). Hunger, hedonics, and the control of satiation and satiety. In: M. I. Friedman, M. G. Tordoff, & M. R. Kare, (Eds.), *Chemical Senses* (Vol. 4) *Appetite and Nutrition* (1st ed.) (pp. 127–148). New York, NY: Marcel Dekker.

Conner, M. T., & Booth, D. A. (1988). Preferred sweetness of a lime drink and preference for sweet over non-sweet foods, related to sex and reported age and body weight. *Appetite*, *10*, 25–35.

Conner, M. T., Haddon, A. V., Pickering, E. S., & Booth, D. A. (1988). Sweet tooth demonstrated: Individual differences in preference for both sweet foods and foods highly sweetened. *Journal of Applied Psychology*, *73*, 275–280.

Drewnowski, A., Grinker J, A., & Hirsch, J. (1982). Obesity and flavor perception: Multidimensional scaling of soft drinks. *Appetite*, *3*, 361–368.

Finlayson, G., King, N., & Blundell, J. (2006). Is it possible to dissociate 'liking' and 'wanting' for foods in humans? A novel experimental procedure. Physiology and Behavior, doi:10.1016/j.physbeh.2006.08.020.

Guinard, J. X., & Brun, P. (1998). Sensory-specific satiety: Comparison of taste and texture effects. *Appetite*, *31*, 141–157.

Guinard, J. X., Caussin, J., Campo Arribas, M., & Meier, J. (2002). Effect of exposure to the aroma of a preload on subsequent intake of a food with the same aroma. *Journal of Sensory Studies*, *17*, 351–363.

Gupta, S. (1988). Impact of sales promotions on when, what, and how much to buy. *Journal of Marketing Research*, *25*, 342–355.

Hirsch, E. S., & Kramer, F. M. (2002). Hedonic ratings as a food choice predictor. *Appetite*, *39*, 239.

Inman, J. J. (2001). The role of sensory-specific satiety in attribute-level variety seeking. *Journal of Consumer Research*, *28*, 105–120.

Johnson, J., & Vickers, Z. (1993). Effects of flavor and macronutrient composition of food servings on liking, hunger and subsequent intake. *Appetite*, *21*, 25–39.

Lähteenmäki, L., & Van Trijp, H. C. M. (1995). Hedonic responses, variety-seeking tendency and expressed variety in sandwich choices. *Appetite*, *24*, 139–151.

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin*, *116*, 75–98.

McAlister, L. (1979). Choosing multiple items from a product class. *Journal of Consumer Research*, *9*, 311–322.

McAlister, L. (1982). Variety seeking behavior: An interdisciplinary review. *Journal of Consumer Research*, *6*, 213–224.

Mela, D. J. (2001). Why do we like what we like? Review. *Journal of the Science of Food and Agriculture*, *81*, 10–16.

Mela, D. J. (2006). Eating for pleasure or just wanting to eat? Reconsidering sensory hedonic responses as a driver of obesity. *Appetite*, *47*, 10–17.

Mela, D. J., & Rogers, P. J. (1998). Food, eating, and obesity: The psychobiological basis of appetite and weight control (1st ed.) (p. 225). London; New York: Chapman & Hall.

Menon, S., & Kahn, B. E. (1995). The impact of context on variety seeking in product choices. *Journal of Consumer Research*, *22*, 285–295.

Pudel, V. (1980). Das rätselhafte Süße. *Ärztliche Praxis*, *31*, 1095.

Raju, P. S. (1980). Optimum stimulation level: Its relationship to personality, demographics, and exploratory behavior. *Journal of Consumer Research*, *7*, 272–282.

Ratner, R. K., Kahn, B. E., & Kahneman, D. (1999). Choosing less-preferred experiences for the sake of variety. *Journal of Consumer Research*, *26*, 1–15.

Rolls, B. J. (1986). Sensory-specific satiety. *Nutrition Reviews*, *44*, 93–101.

Rolls, B. J., Hetherington, M., & Burley, V. J. (1988). The specificity of satiety: The influence of foods of different macronutrient content on the development of satiety. *Physiology and Behavior*, *43*, 145–153.

Rolls, E. T., & Rolls, J. H. (1997). Olfactory Sensory-Specific Satiety in Humans. *Physiology and Behavior*, *61*, 461.

Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annual Review of Nutrition*, *6*, 433–456.

SAS Institute. (2001). SAS/STAT software: changes and enhancements, release 8.2. (p. 324). Cary, NC: SAS Institute Inc.

Simonson, I., & Winer, R. S. (1992). The influence of purchase quantity and display format on Consumer preference for variety. *Journal of Consumer Research*, *19*, 133–138.

Tuorila, H., Kramer, F. M., & Engell, D. (2001). The choice of fat-free vs. regular-fat fudge: the effects of liking for the alternative and the restraint status. *Appetite*, *37*, 27–32.

Tuorila, H., & Pangborn, R. M. (1988). Prediction of reported consumption of selected fat-containing foods. *Appetite*, *2*, 81–95.

van Trijp, H. (1995). *Variety-seeking in product choice behavior: Theory with applications in the food domain*. Wageningen: The Netherlands.

Van Trijp, H. C. M., Hoyer, W. D., & Inman, J. J. (1996). Why switch? Product category-level explanations for true variety-seeking behavior. *Journal of Marketing Research*, *33*, 281–292.

Vickers, Z. (1999). Long Term Acceptability of Limited Diets. *Life Support & Biosphere Science*, *6*, 29–33.

Vickers, Z., & Holton, E. (1998). A comparison of taste test ratings, repeated consumption, and post consumption ratings of different strengths of iced tea. *Journal of Sensory Studies*, *13*, 199–212.

Weingarten, H. P., & Elston, D. (1991). Food cravings in a college population. *Appetite*, *17*, 167–175.

Zuckerman, M. (1979). Sensation seeking: beyond the optimal level of arousal. Hillsdale, N.J.; New York: L. Erlbaum Associates; distributed by the Halsted Press Division of Wiley.