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Chocolate Craving and Liking

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Liking and craving for chocolate and related substances were surveyed in a sample of University of Pennsylvania undergraduates ($n=249$) and their parents ($n=319$). Chocolate was highly liked in all groups, with a stronger liking by females. Chocolate is the most craved food among females, and is craved by almost half of the female sample (in both age groups). Although this craving is related to a sweet craving, it cannot be accounted for as a craving for sweets. About half of the female cravers show a very well defined craving peak for chocolate in the perimenstrual period, beginning from a few days before the onset of menses and extending into the first few days of menses. There is not a significant relation in chocolate craving or liking between parents and their children. The current motivation for chocolate preference seems to be primarily, if not entirely, sensory. Liking for chocolate correlates significantly with liking for sweets and white chocolate. The liking for the sensory properties could originate in innate or acquired liking based on the sweetness, texture and aroma of chocolate, or it could be based in part on interactions between the postingestional effects of chocolate and a person's state (e.g., mood, hormone levels). Based on correlational data, we find little evidence for a relation between addiction to chocolate or the pharmacological (e.g., xanthine-based) effects of chocolate and the liking for chocolate.

Introduction

"Caviar is exquisite, but people don't declare their love with ten-pound heart-shaped boxes of it. Fresh figs are heavenly, but you don't find them on your hotel pillow at night. Entire magazines are not devoted to lobster or asparagus. No one makes 3:00 AM runs to the 7-Eleven for butterscotch. But chocolate . . . chocolate inspires a passion normally reserved for things grander than food" (Roach, 1989, p. 135). Chocolate does indeed represent a passion at least among many in Western/industrialized countries.

A discussion of chocolate requires a distinction between four terms: use, preference, liking and craving (see Rozin, 1979). Use refers to the objective measurement of amount consumed. Evidence of chocolate popularity in terms of use includes the fact that per capita intake of chocolate among Americans in the 1970s was 1·6 kg/year; the corresponding figure for Switzerland is 3·6 kg/year (Shively & Tarka, 1984). Preference requires a choice between alternatives. Liking is a subjective measure of attitude to a food, and often constitutes the principal account for

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preference. Evidence for the high degrees of liking for chocolate comes from a survey of American military personnel, including liking ratings for 416 foods. Chocolate milk ranked sixth (Meiselman *et al.*, 1972). There is no accepted definition of craving, but it would seem to be a special case of liking, which is particularly intense, motivates behavior aimed at gaining the craved substance, and is periodic. In a survey of craving (defined as an "intense desire to eat a specific food") in university students, chocolate was mentioned more frequently than any other food by female college students (Weingarten & Elston, 1991). In addition, in a prospective, repeated-measures survey of healthy adult women, Rodin *et al.* (1991) report that chocolate and ice cream are the most commonly mentioned craved substances.

Chocolate comes from Mexico, and was introduced to the Old World by the early Spanish explorers. Its incredible success in the Old World (and then back into the U.S.A. and Canada) is a testimony to its great appeal. Historically, this wide and enthusiastic acceptance was related to the availability of sugar as a cheap additive that converted chocolate from a basically bitter to a basically sweet food (Mintz, 1985).

In this paper, we address some of the basic features of the liking and craving for chocolate. Through correlational analysis, we also tentatively explore some possible current motivations for liking, as well as some developmental causes of these current motivations. In the introduction, we briefly consider some properties of chocolate that might lead to strong liking or craving.

A first and very appealing account for chocolate liking is purely sensory. Chocolate has a set of extremely appealing sensory characteristics. It is both high in sugar and in fat, a combination that is known to be of particular appeal (Drewnowski & Greenwood, 1983), and which is, at least in part, innate in origin. Cocoa butter (the fat in chocolate) has the property that it melts at body temperature, producing a distinctive and very pleasant oral sensation. Chocolate also has a very attractive aroma. These sensory properties might be sufficient to explain the current motivation for ingesting chocolate: it is liked and craved because it tastes and smells good. In a general review of cravings, Weingarten & Elston (1990) emphasize the importance of sensory characteristics in accounting for cravings. It may be that the motivating positive chemosensory characteristics of chocolate do not need to be explained in terms of other factors, developmentally. That is, chocolate may have innate appeal, on account of its sweetness and texture, and other sensory features may have become positive by association with these possibly innate characteristics.

Some chocolate preference or use may be motivated by features other than sensory properties. For example, there are a few reports in the literature suggesting that individuals use chocolate as self-medication for depression (Schuman *et al.*, 1987; Smith & Sauder, 1969; but see Cohen *et al.*, 1987). Negative mood states and hunger are associated with the onset of craving, in general (Hill *et al.*, 1991). Of course, negative mood might express itself as an enhanced liking for chocolate, so that chocolate ingestion under such circumstances could still be motivated by sensory properties. [There are also suggestions that dieting or energy deprivation may lead to craving, but two recent studies cast serious doubts on this hypothesis (Hill *et al.*, 1991; Rodin, *et al.*, 1991).]

Even if motivation for current consumption of chocolate is primarily or entirely chemosensory, it is possible that this state of affairs came about by association of these chemosensory properties with significant postingestional effects of chocolate.

Chocolate contains many substances that are biologically active, so that liking or craving might have a pharmacological or addictive basis. Most prominently, chocolate contains high levels of the xanthine, theobromine, and lower but perhaps significant levels of the more familiar xanthine, caffeine. For example, the typical 1·65-oz Hershey milk chocolate bar contains 10 mg of caffeine (22 mg/100 g) and 92 mg of theobromine (197 mg/100 g) (Keith Hostetler, Hershey Foods, personal communication). (For comparison purposes, a cup of coffee contains 80–100 mg of caffeine and no theobromine). Theobromine is not a well investigated drug, but it seems to have effects similar to those of caffeine, although theobromine is less stimulating (Tarka, 1982). Since caffeine can be addictive, it is likely that theobromine can be as well. These is no data in the literature implicating either theobromine or caffeine as a component of chocolate liking or craving, although there is abundant evidence that coffee consumption is related to its caffeine content. It is striking that coffee, chocolate and tea are three of the most popular ingestants in the world, and that they are also the principal dietary sources of xanthines.

Chocolate contains some biogenic amines, a set of compounds including tyramine and phenylethylamine that tend to be arousing and tend to raise blood pressure. Although the levels of these substances are significant in chocolate, and well above those in many foods, they are substantially lower than levels in certain foods, such as cheddar cheese or pickled herring, for the case of tyramine (Hurst *et al.*, 1982).

Finally, chocolate is very high in magnesium; among 27 dietary magnesium sources listed in one reference, cocoa, at 420 mg/100 g, had the highest level; the next highest was cashew nuts at 267 mg/100 g (Burton & Foster, 1988). It has been suggested that chocolate ingestion may be motivated in some cases by magnesium deficiency, and it has been reported that in a few cases, doses of magnesium relieved chocolate craving (Weil, 1990).

In addition to the presence of biologically active substances in chocolate, there is evidence from behavior that chocolate intake, craving or liking may be influenced by state variables, such as mood (see discussion of self-medication, above) or hormone levels. There are suggestions of a linkage between chocolate craving and the menstrual cycle. This may be accounted for, at least in part, by a craving for sweets. Craving for sweets is considered a characteristic of the premenstrual syndrome (Rein & Yen, 1981). This may be related to reports of hypoglycemia in this period (Morton *et al.*, 1953), although the existence of hypoglycemia in the premenstrual syndrome is in question (Reid *et al.*, 1986). An increase in cravings during the luteal stage (the period of about 10 days prior to menstruation) has been reported (Cohen *et al.*, 1987) in a prospective study (with a sharp drop in craving at the time of menses). A recent study that included measurements of sweet liking and intake in a laboratory setting reports enhanced effects of sweets in roughly the same period (Bowen & Grunberg, 1990).

Three studies directly address the relation of chocolate craving to the menstrual cycle. Smith & Sauder (1969), in a study of 300 nurses (age range 19–59) report an association between menstrual cycle and chocolate craving. The actual question in this study was "Do you ever develop a craving for chocolate at the time of your periods?" (or, "Do you ever develop a craving for chocolate when you are tense or depressed"; results presented combine responses to these two questions). Positive answers to these questions (which do not single out premenstrual craving) correlated with reported premenstrual water retention and depression.

Tomelleri & Grunewald (1987) did a prospective study, in which subjects filled out weekly questionnaires, hence dividing the cycle into four phases. Craving for 32 foods was examined each week. The craving survey included five items containing chocolate, as well as a checklist of 15 menstrual symptoms. Chocolate craving was related to sweet craving by comparing items that differed only in the presence of chocolate (e.g. chocolate vs. non-chocolate cake). They report greater preference for chocolate during the menstrual flow, and this was not associated with an increase in sweet craving.

Weingarten & Elston (1991) carried out a craving survey on 1,138 Canadian undergratuates. The open-ended questionnaire simply asked about craved foods. It did not mention chocolate or any other food. Women mentioned chocolate more frequently than any other substance as a craved food. Thirty-two per cent of women with any kind of food craving linked them to the menstrual cycle (no specific time is reported). There was a marginal tendency for women describing a correlation between menstrual cycle and craving to report chocolate as their most craved item (45%), as opposed to women who reported no menstrual-craving association (38%).

Altogether, there seems to be some confusion as to the degree of localization of chocolate craving within the menstrual cycle, and even in the positive studies, there are differences in reports about the precise temporal location of the craving.

Any consideration of chocolate preference must recognize that chocolate as usually consumed is very sweet, so that chocolate preference may be confounded with sweet (sugar) preference. (On the other hand, chocolate is also a high fat food, and should not be casually classified as a carbohydrate.) Chocolate seems to be more widely craved and more highly preferred than other very sweet items (Weingarten & Elston, 1991). Some studies reported a very high association between chocolate and sweet preference. In the most detailed study, in which separate scales for sugar and chocolate consumption/preference were developed, the correlation between the two scales was 0·75 (Schuman *et al.*, 1987). Smith & Sauder (1969) report that 85% of those who crave chocolate also crave sweets. On the other hand, Tomelleri & Grunewald (1987) report chocolate-specific craving enhancement in association with menstruation, and Weingarten & Elston (1991) report that 77% of female and 75% of male chocolate cravers say there is no non-chocolate substitute when they crave chocolate.

There is clearly a major phenomenon of chocolate craving, and evidence for some linkage to the menstrual cycle. Understanding of the specific hormonal correlates of that linkage depends on a clearer delineation of the time of the chocolate craving. We still do not know what postingestional effects of chocolate (if any) influence chocolate consumption, and whether any of these also affect chocolate liking. Similarly, although the pharmacological effects of coffee (caffeine) are much better defined than those of chocolate, it is not clear how important these effects are in the liking for coffee (Cines & Rozin, 1982). In particular, given the clear addictive component of some cases of coffee drinking, it would be of interest to explore an addictive explanation of chocolate liking and intake.

The present study is an attempt to extend the data base on chocolate liking and craving, and to address some questions about current motivations for chocolate consumption, and the development of these motivations. Unlike most of the preceding studies on craving, this study includes a large sample of mature adults; the total sample consisted of a large class of University of Pennsylvania undergraduates and their parents. The survey included: 1. specific questions on liking and intake for

chocolate and related substances (including other xanthine-containing items); 2. specific open-ended questions on chocolate craving and substitutes, and questions (retrospective) about the occurrence of chocolate craving on particular days in the menstrual cycle; and 3. specific ratings of "addiction" to chocolate and related substances, defined in terms of four defined features: craving, withdrawal, lack of control and tolerance;

METHOD

A survey on body image, addiction, chocolate liking and craving was distributed to every member of an introductory psychology lecture class (270 registered students). Students were also given copies of the same questionnaire for their parents, in an outer envelope with a stamped envelope addressed to the experimenters enclosed. Students addressed the outer envelope to their parents, and were encouraged to write a note to their parents at the bottom of the introductory letter accompanying the questionnaire. It is believed that this welcome note home increases compliance rate of parents. The students and parents were told that the results from the survey would be shared with the class, and they were.

Two parts of the survey are relevant to this study. The first was a set of questions designed to determine whether there is a correlation in degree of addiction to ten different addictive substances or activities. The data from this survey will be reported in another source, but of particular relevance to this study are the reponses to addiction for chocolate. Subjects were given the following instructions (for each of the substances):

"We are interested in the extent to which people can become 'addicted' to various activities or substances. For current purposes, we will define addiction as involving craving, withdrawal, loss of control, and tolerance. We define a CRAVING as a strong desire, occurring at least a few times a month. This desire is so strong that it will cause a person to go far out of his or her way to satisfy the craving. For each of the activities and substances below rate your craving on the 1–3 scale listed above the list of substances. Write the craving ratings in the first column then return and read about withdrawal.

"WITHDRAWAL has to do with the presence of physical discomfort resulting from abstaining from eating, drinking or engaging in the activity of concern for a certain period of time. Using the 1–3 scale, please answer the questions about withdrawal in the second column below, and then return to the next paragraph.

"LACK OF CONTROL is difficulty in stopping the consumption of the indicated substance or the indicated activity. Using the 1–3 scale, please answer the questions about lack of control in the third column below, then return to the next paragraph.

"TOLERANCE means that individual doses (portions, levels) of the substance or activity in question produce less of an effect than they used to. Using the 1–3 scale, please answer the questions about tolerance in the fourth column below."

The 1–3 scale used was: 3 = strong, definite, 2 = weak, partial, 1 = none.

Following this section, subjects were asked: "What is your strongest craving for a food or drink (it need not be included on the list above)?"

In part of the survey specifically related to chocolate, intake of xanthine-related items was gauged, in terms of cups per week of caffeinated coffee and tea, times per week for chocolate, and cans (10 oz) per week of cola beverates with caffeine.

Subjects were asked to rate liking on the standard 9-point hedonic scale (9 = like extremely to 1 = dislike extremely, with 0 = don't know/never tried). Items reported in this paper are chocolate, three items that have a pharmacological similarity to chocolate on account of xanthine content (hot coffee, tea, and cola beverages), and three items that share sensory but not pharmacological properties with chocolate (white chocolate, carob, and non-chocolate sweets).

The section on chocolate craving followed:

"We define craving as a strong desire. This desire is so strong that it will cause a person to go far out of his or her way to satisfy the craving. Do you crave chocolate? Yes/No. If so, answer the following four questions.

"Are there any times when you particularly crave chocolate? If so indicate the time(s).

"What form(s) of chocolate do you crave, when you crave it?

"At a time when you crave chocolate and cannot get any chocolate, what, if anything, do you seek to eat instead (e.g. white chocolate, non-chocolate candy, carob, coffee, plain milk, etc.)

"When you crave chocolate, do you also crave non-chocolate sweets? Yes/No".

The following three questions were for females, only.

"Do you tend to crave chocolate at a particular point during your menstrual cycle? Yes/no. If yes, indicate the time in the cycle in terms of days before or days after the beginning of your flow (−3 means 3 days before the beginning of your flow, +4 is 4 days after, with 1 = first day of your flow). Most intense craving from day # to day #

"Are you taking the pill? Yes/no. If so, which particular pill do you take?

Is the chocolate craving present during months in which you are on the pill? Yes/no."

RESULTS

The data base consists of usable returns from 123 male students (referred to as sons), 126 female students (daughters), 157 fathers and 162 mothers. (For the data on family resemblance, results come from 127 complete families, in which data from both parents were available, and the parents were biological parents still living together). Mean ages were 19·3 years for sons, 18·7 years for daughters, 49·4 years for fathers and 46·0 years for mothers. The most substantial racial representation in the sample was 82% white and 14% Asian-American. The major religious affiliations in the sample were 44% Jewish (in accordance with the Jewish representation at the University of Pennsylvania), 24% Protestant, and 21% Catholic. In this respect, the sample greatly over-represents Jews, with respect to a U.S. national sample.

Baseline Characteristics of Chocolate Liking and Craving

The liking for and intake of chocolate and related substances

The sample surveyed in this study, because of its size and age diversity, offers an opportunity to enrich the baseline data on chocolate intake, liking and craving in Americans. For this reason, in this section, we present information on base rates, analyzed in terms of gender and religious background. Liking scores for chocolate

TABLE 1
Liking for chocolate and related substances by age and sex 1#

Food item	Sons	Daughters	Fathers	Mothers	*F*(sex)	*F*(age)	*F*(SXA)
Chocolate	7·61	8·00	7·20	7·65	12·7***	7·3**	0·6
Coffee	4·73	5·07	6·67	6·50	0·2	63·9***	1·5
Tea	5·76	6·16	5·94	6·22	4·2*	0·5	0·2
Cola beverages	7·25	6·88	6·56	6·31	4·4*	19·0***	0·2
White chocolate	6·10	6·62	5·93	5·76	1·3	10·0**	4·3*
Carob	4·63	5·38	4·73	4·67	3·9	2·9	5·2*
Sweets	6·43	7·09	6·49	6·68	12·1**	2·1	3·9*

All ratings on standard 9-point hedonic scale, with 9 = like extremely. Range of Ns for each subject category are as follows, for all items but carob. Sons (111–123), Daughters (111–126), Fathers (142–157), Mothers (156–161). Values for carob are 72, 94, 99, and 110 respectively. Note that at most 127 of each of the parent categories are spouses, and their children (61 sons, 66 daughters) are included in this sample. Thus the four categories are only partly independent.

*$p<0·05$; **$p<0·01$; ***$p<0·001$.

and other substances are presented in Table 1, by son, daughter, father and mother. High ratings, above 7·00 on the nine-point hedonic scale for each of the four subject groups, testify to the popularity of chocolate. The score for chocolate is highest of the seven items sampled for all groups. Using the hedonic ratings from the Meiselman *et al.* (1972) survey of 416 foods (not including chocolate, *per se*), which used the same 9-point scale as in the present study, chocolate ratings from the present study would tie for third for sons, rank second for daughters (milk is first), tie for 14th most liked for fathers, and tie for second (with orange juice) for mothers.

There is a significant tendency for females to like chocolate more than males in both age groups; this holds for sweets and tea, as well. Males prefer cola beverages. There is a significantly higher tendency for Jews to like chocolate, an effect which appears clearly in all groups except sons (Table 2). A 3-way ANOVA (using the three religion categories of Jewish, Protestant and Catholic) on the results in Table 2 shows significant main effects for sex [$F(1,473)=13·67$, $p<0·001$], religion [$F(2,473)=8·40$, $p<0·001$] and age [$F(1,473)=3·91$, $p<0·05$], and a significant interaction between religion and age [$F(2,473)=3·4$, $p<0·05$] such that the greater Jewish chocolate preference is more pronounced in the older group.

There is significantly more frequent intake of chocolate in females (Table 3), and a greater chocolate intake in younger people. There is also a greater intake of tea in younger people, but a substantially higher intake of coffee in the parents. In terms of

TABLE 2
Ethnic differences in chocolate liking. (All values on 9-point hedonic scale; n *in parenthesis)*

Religion	Sons	Daughters	Fathers	Mothers
Jewish	7·59 (44)	8·25 (53)	7·69 (74)	8·10 (71)
Protestant/Catholic	7·55 (53)	7·71 (51)	6·95 (65)	7·55 (75)

TABLE 3
Frequency of intake of chocolate and other xanthine items

Food item	Sons	Daughters	Fathers	Mothers	*F*(sex)	*F*(age)	*F*(SXA)
Chocolate[a]	2·63	3·15	1·79	2·23	5·0*	13·6***	0·0
Coffee[b]	1·39	1·97	10·3	8·51	0·7	112·7***	2·6
Tea[b]	1·12	2·02	3·38	4·59	3·8	21·3***	0·0
Cola beverages[c]	9·43	8·02	3·66	2·42	3·0	70·2***	0·1

[a]times/week.
[b]cups/week.
[c]10 oz. cans with caffeine/week.
ns: Sons 117–122; Daughters 124–125; Fathers 146–148; Mothers 151–155.

xanthine intake, there is thus a shift toward coffee as the source, with increasing age (Table 3).

Family resemblance in chocolate and related likes and chocolate craving

In keeping with the literature on family resemblances in food likes (e.g. Pliner, 1983; Rozin *et al.*, 1984; Rozin, 1991), family resemblances in chocolate and related likings or intake are surprisingly low (Table 4). No value exceeds 0·34. In spite of the substantial *n* (over 110 families in all cases), the only significant chocolate correlations are for mother and father (0·27 for chocolate liking, 0·25 for white chocolate liking and 0·25 for chocolate intake). The largest family resemblance for both parents and parent-child measures have to do with cola beverage intake (Table 4).

There is not a significant relation ($\chi^2 = 0{\cdot}65$) between chocolate craving in mothers and their daughters (contingency coefficient = 0·10).

Chocolate craving

Subjects were asked "What is your strongest craving for a food or drink?" Chocolate or a chocolate product was mentioned by 9·4% of sons, 20·1% of daughters, 8·1% of fathers and 22·9% of mothers (Table 5).

TABLE 4
Family resemblance for chocolate liking, intake and related measures (N = *127 families*)

Food item	Mother-Father *r*	Mid-parent child *r*
Chocolate—like	0·27**	0·17
Coffee—like	0·15	0·29**
White chocolate—like	0·25**	0·10
Sweets—like	0·07	0·14
Chocolate—intake	0·25**	−0·02
Coffee—intake	0·24*	0·17
Cola—intake	0·34***	0·32***
Tea—intake	0·02	0·03

t-tests: $*p < 0{\cdot}05$; $**p < 0{\cdot}01$; $***p < 0{\cdot}001$.

TABLE 5
Chocolate craving by group

Food item	Sons	Daughters	Fathers	Mothers
Strongest craving (% total)	9·4	20·1	8·1	22·9
Total *N*	123	126	157	162
No. of chocolate cravers	20	54	24	60
No. of above who crave non-chocolate sweets	8	24	9	23

There is a clear predominance of females, by more than 2:1 in either generation, whether classification is based on indication of a craving for chocolate or listing of chocolate as the most intense craving. The incidence of chocolate craving is higher in females for both the younger generation ($\chi^2 = 21{\cdot}08$, $p < 0{\cdot}001$) and parents ($\chi^2 = 19{\cdot}44$, $p < 0{\cdot}001$).

Chocolate and sweet craving and chocolate substitutes

Less than half of subjects in all groups claim to crave non-chocolate sweets when they crave chocolate (Table 5). Another approach to understanding the basis of the craving is to examine what chocolate cravers consume when chocolate is not available. Under these conditions, over half of the reported substitutes are classified (by the experimenters) as sweet. Included in this category are cookies, milk, ice cream, soda, juice and fruit. This liberal definition probably accounts for the higher incidence of sweet substitutes, in comparison to sweet cravings.

Menstrual and premenstrual chocolate craving

Of 54 daughter cravers, 30 (55·6%) report a menstrual-related cyclicity in the craving. The corresponding figures for mothers are 60 cravers and 35 menstrual-related cravers (58·3%). The pattern of craving is illustrated in Figures 1 and 2. Figure 1 shows the data for daughters; each reported day of craving is scored for each subject. Thus a subject who reports craving from days -2 to $+1$ would score a point on each of these days. Note that the 30 daughter cravers cluster almost exclusively around the beginning of menses, with a peak just before the onset of menses (modal day is day -2). The pattern is very similar for mothers (Figure 2), with the modal day at -1. Thus, the craving is best described as perimenstrual, encompassing the period of a few days prior to and subsequent to the onset of menses.

Female chocolate liking and menstrual-related craving

The greater female liking for chocolate might result from the special menstrual-related craving that is limited to females. To make this determination, we compare the chocolate liking scores of non-menstrual-cycle-craving females with the scores of males. For both children and parents, the female chocolate score is reduced, and is now absolutely higher, but not significantly higher than the male score (Table 6).

Since only eight female subjects were on birth control pills, we could not perform a meaningful comparison of this group with the remaining females.

Explanations of Chocolate Liking and Craving

Sensory basis for liking chocolate

There is correlational data from this study that provides modest support for the common belief that people like chocolate because it tastes good. Correlations with chocolate-related items (white chocolate and sweets) are positive. However, the correlation with non-chocolate sweets is about as high as the correlation with white chocolate, and none of these correlations are strikingly high (Table 7). Sweetness is a major sensory attribute of chocolate. Consistent with this point, the only significant xanthine correlation with chocolate liking is cola beverages, which are themselves sweet (see next section).

Xanthines and chocolate liking and intake

To what extent can we account for chocolate intake and liking in terms of the effects of the xanthines, and perhaps addiction to them? Insofar as the pharmacological effects promote liking, we might expect correlated likings for xanthine-containing beverages and foods. (There is no necessary relation between a xanthine base for liking chocolate and coffee, but the most straightforward prediction would be correlated liking.) However, the correlations are extremely low (Table 7). The only significant correlation is for cola-chocolate liking in females, and this may be mediated by the common sensory property of sweetness.

Although there is a higher preference in females for chocolate, this does not appear for two (cola and coffee) of the three other xanthine sources (Table 1). Similarly, in terms of frequency or amount of intake, correlations (calculated across all subjects) of chocolate with coffee ($r = -0{\cdot}07$) and tea ($r = -0{\cdot}08$) are very low, while correlations with cola beverages are higher ($r = 0{\cdot}21$, $p < 0{\cdot}001$), but, again, this may be accounted for as a sensory (sweetness) resemblance.

Overall, these correlation data do not support a strong xanthine base for liking for chocolate, although they do not eliminate this possibility. The results on intake are difficult to interpret, because one might not predict a positive correlation even in the face of a xanthine dependence; one might assume that a person typically got his

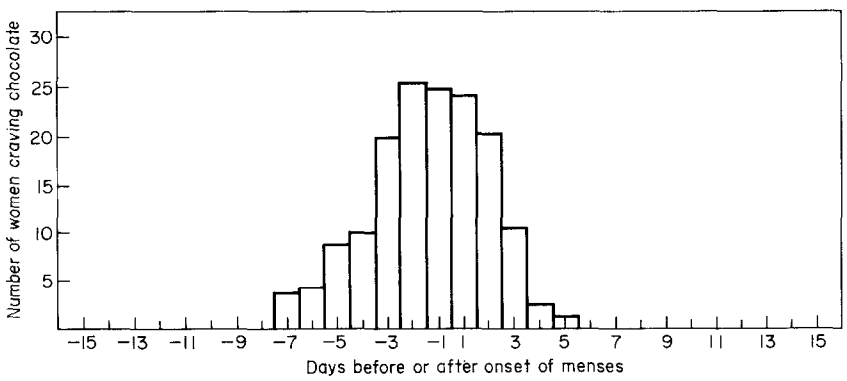

FIGURE 1. Number of 30 daughter cyclical chocolate cravers (mean age: 18·7 years) who crave chocolate on each day of the monthly cycle. Each reported day of craving is scored for each subject. Thus a subject who reports craving from days −2 to +1 would score a point on each of these days.

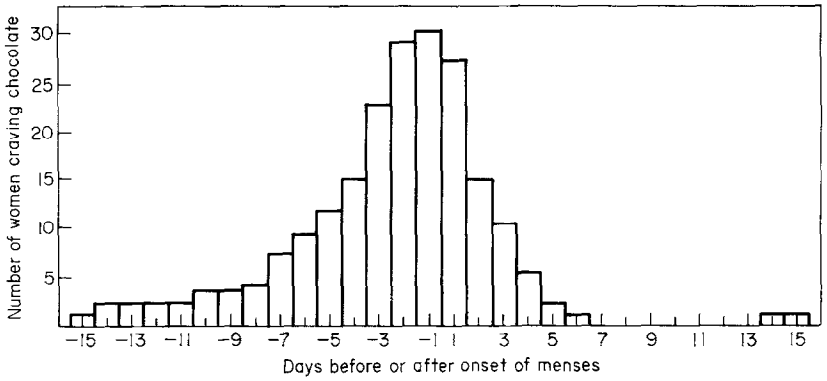

FIGURE 2. Number of 35 mother cyclical chocolate cravers (mean age: 46·0 years) who crave chocolate on each day of the monthly cycle. Each reported day of craving is scored for each subject. Thus a subject who reports craving from days −2 to +1 would score a point on each of these days.

or her xanthines from one of the alternatives, so that intakes might not be correlated, or might even be negatively correlated.

Chocolate addiction

As indicated in the introduction, addiction is a possible account for chocolate liking. By our criterion for addiction (the summed 1-3 scores on craving, withdrawal, tolerance and lack of control), there is not a strong addiction, over all, to chocolate (we also include coffee, for comparison) (Table 8, note that 4 is the minimum score, and 12 the maximum). The highest chocolate mean addiction score (6·50) is for daughters. As with our other analyses of chocolate liking and craving, there is a significant gender, but not a significant age effect nor a significant interaction (Table 8). If we consider addiction scores of 8 or greater as indicating substantial addiction, then 14% of sons, 33% of daughters, 14% of fathers and 25% of mothers qualify. It is noteworthy that addiction scores are not higher for coffee (Table 8), although there is a documented phenomenon of caffeine addiction in a minority of coffee drinkers. Of the criteria for addiction, chocolate craving is

TABLE 6
Chocolate liking by sex, excluding female menstrual related cravers

Group	*N*	mean	*SD*	*t* vs. opposite sex
All sons	119	7·61	1·11	
All daughters	126	7·92	1·12	2·79**
Non-cycle craving daughters	95	7·69	1·15	1·33
All fathers	157	7·25	1·43	
All mothers	161	7·69	1·37	2·38*
Non-cycle craving mothers	122	7·39	1·41	0·45

TABLE 7
Correlations for liking of chocolate with sensory and pharmacologically related items

Food item	Sons	Daughters	Fathers	Mothers	Mean[a]
Sensory-related					
White chocolate	0·34***	0·17	0·49***	0·11	0·27***
Carob	−0·24*	0·16	0·30**	−0·08	0·06
Non-chocolate sweets	0·26**	0·21*	0·35***	0·38***	0·33***
Pharmacology-related					
Coffee	−0·07	0·05	0·03	0·00	−0·03
Tea	−0·09	0·02	0·14	−0·07	0·01
Cola beverages	0·02	0·24**	0·11	0·33**	0·20***

t tests $*p<0·05$; $**p<0·01$; $p<0.001$.
[a]Mean represents correlation generated by all subjects, and not the mean of the four correlations of the individual groups. *t* values are assigned to these means, but the subjects are actually not completely independent, since many of the subjects constitute family groups.

indicated (weak or strong) by the greatest number of subjects (57%), followed by lack of control (36%), withdrawal (24%) and tolerance (19%).

Further argument against a xanthine hypothesis is the lack of a significant correlations between chocolate addiction scores and addiction scores for coffee (*r* across all subjects in the four groups between chocolate and coffee: 0·12).

DISCUSSION

Our results confirm past reports of a great liking for chocolate among Americans, and a high degree of craving for it, especially among women. Our data are consistent with the consensus result of the few previous studies (see introduction) in indicating that there is a relation between chocolate and sweet craving, but that a major component of chocolate craving is independent of sweet craving. Our results clarify the previous reports of menstrual-related chocolate craving. We find that a substantial chocolate craving occurs in about half of the female cravers (or about a quarter of all females) in the perimenstrual period, covering the last few premenstrual days and the first few days of menstruation. This perimenstrual craving may account for the enhanced liking for chocolate in women, in comparison to men. Our data on perimenstrual craving is the most precise demarcation of this craving so far reported (because questions were specifically asked based on day of onset and offset). However, these are retrospective data. The clear uniformity of response in

TABLE 8
Addiction scores for chocolate and coffee

Food item	Sons	Daughters	Fathers	Mothers	*F*(sex)	*F*(age)	*F*(SXA)
Coffee	4·51	4·98	6·11	5·99	1·34***	38·48***	3·15
Chocolate	5·51	6·50	5·35	6·12	29·22***	3·34	0·16

both mothers and daughters and the fact that two other prospective studies report a generally similar timing of chocolate craving (Smith & Sauder, 1969; Tomelleri & Grunewald, 1987) lend credence to our retrospective data, but there are still inconsistencies in the literature.

The evidence we present concerning evaluation of different explanations of chocolate liking and craving is correlational, and hence is not definitive. The correlations we report between liking for sugar, white chocolate and carob and liking for chocolate argue weakly for a significant sensory basis for chocolate craving. These substances share chocolate's sensory properties, but not its pharmacological properties. On the other hand, none of these substances share chocolate's aroma, and only one (white chocolate) shares its mouth-melting texture, the two most distinctive features of chocolate. Under the circumstances, assuming a primarily sensory basis for liking and craving, one might not expect a high correlation with chocolate "substitutes".

The low (non-significant) correlations of chocolate liking and intake with liking and intake of other xanthine-containing substances, and the low (non-significant) correlation between coffee and chocolate addiction scores argue against a major role for theobromine addiction in chocolate intake or liking. Our data do not speak to roles for biogenic amines or magnesium in chocolate liking or intake.

The strong craving for the sensory properties of chocolate remains to be explained. The periodic nature of cravings suggests that some internal state is involved. The perimenstrual craving data implicate one set of relevant states, hormonal status. The fact that the craving is *peri*menstrual is quite consistent with a hormonal basis, since the hormonal environment in the period just before menstruation is very similar to the environment during menstruation: both time periods are characterized by low levels of both progresterone and estrogen. However, in our sample, only one-third of all chocolate cravers show this perimenstrual pattern. The causes of chocolate craving in the remaining men and women are yet to be determined. Our data suggest that the causes may be the same in these women and men, since the liking for chocolate does not differ significantly across gender, when the perimenstrual cravers are excluded.

Further research on chocolate should seek to evaluate a possible role for postingestional effects of chocolate on the development of craving and liking. This would include experimental study of the effect of magnesium, theobromine or biogenic amine administration on the craving for chocolate. The perimenstrual craving could be explored by comparing hormone levels in perimenstrual cravers and non-cravers, or by hormone supplementation studies. We are engaged in a number of studies to explore these issues.

The evidence we report suggests that chocolate craving and liking are motivated principally by a desire for the sensory properties of chocolate. This desire may originate, in large part, from cognitive factors. However, the marked perimenstrual craving suggests that, at least in some cases, there is a hormonal component to craving. The episodic nature of craving suggests that some type of internal-state factors will be involved in the ultimate explanations.

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