Flavor-Flavor and Color-Flavor Conditioning in Humans

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Pavlovian flavor-flavor associative learning has been suggested as one of the determinants of humans' food likes and dislikes (e.g., Rozin & Zellner, 1985). However, few experimental studies exist which directly examined this proposal. In the present study, the hypothesis was tested that the contingent presentation of a neutral flavor (CS) with an already (dis)liked flavor (US) should result in an increase (or decrease) in liking for the originally neutral flavor. Second, the question was addressed whether or not a perceptual characteristic of food other than its flavor (c.q. its color) may also acquire evaluative value when paired with an appetitive or an aversive flavor US. Finally, the relationship was studied between evaluative conditioning and subjects' explicit knowledge of the stimulus relationships presented during the conditioning phase. In a differential conditioning paradigm, subjects drank 12 CS+/US compound fluids and 12 CS- fluids. Sugar was used as a positive US, and Tween20 as a negative US, while either the flavor or the color of the drink was scheduled as the CS. As indexed by postconditioning visual analog scale ratings, a strong differential evaluative conditioning effect was observed in the flavor-flavor, negative condition. The evidence for positive flavor-flavor conditioning was weak at best, and no evidence was obtained for color-flavor conditioning. On the other hand, none of the subjects in flavor-flavor groups evidenced any explicit knowledge of the CS-US relation, whereas about half of the color-flavor subjects did so. These results are related to the theoretical issues of *positive/negative asymmetry*, *selective associations*, and *implicit/explicit knowledge dissociations*. © 1990 Academic Press, Inc.

Food and liking entertain a privileged relationship. On the one hand, few categories of objects elicit as clearcut and immediate reactions of liking or disliking, as food typically does in humans. On the other hand, like-dislike reactions represent one of the major determinants of (indi-

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vidual differences in) food acceptance or rejection (Rozin & Vollmecke, 1986; Rozin & Zellner, 1985). It is remarkable however, that so little is known about the mechanisms of human food evaluation (Casey & Rozin, 1989; Rozin, 1984). For example, even when it is generally acknowledged that the vast majority of an individual's food likes and dislikes are acquired and molded by experience rather than fixed and biologically innate (Rozin, 1988; Rozin & Vollmecke, 1986), very few well-controlled laboratory studies exist that focus on the processes involved in the acquisition and/or alteration of humans' evaluative reactions to foods.

In the sparse relevant literature, Pavlovian associative learning has been proposed as one plausible candidate for the explanation of acquired food likes and dislikes in humans (Rozin & Zellner, 1985). In its most general form, this proposal amounts to the idea that the evaluative value of food items (CSes) may be altered by the evaluative value of stimuli or events (USes) presented contingently with the food in question. More specifically, two different Pavlovian paradigms have been identified in which human food likes/dislikes may be modified: the flavor-postingestional-consequences paradigm and the flavor-flavor-association paradigm. Also, social influences on human food likes/dislikes may be partially explained by the operation of Pavlovian mechanisms (e.g. Birch, 1986; Rozin & Fallon, 1987).

In the prototypical *flavor-postingestional-consequences* paradigm, it can be demonstrated that the flavor of a food becomes intrinsically disliked, after contingent presentation of this flavor with a nausea/vomiting producing stimulus. This paradigm refers to what has become famous in the animal conditioning literature as conditioned taste aversion learning (Garcia & Koelling, 1966). An experimental demonstration of this kind of learning in humans was obtained by Bernstein and Webster (1980), who observed an acquired dislike for a new flavor given to cancer patients prior to their nausea/vomiting inducing chemotherapy (see also Van den Bergh, Van Huyck, Eelen, & Baeyens, 1989). Also, Arwas, Rolnick, and Lubow (1989) demonstrated conditioned taste aversion in humans using motion-induced sickness as the US. Additional evidence for this route to acquired dislikes for food was obtained in questionnaire studies by Logue, Ophir, and Strauss (1981), Pelchat and Rozin (1982), and Rozin (1986). On the other hand, acquired *likes* in the flavor-postingestional-consequences paradigm were obtained in a study by Booth, Mather, and Fuller (1982), who demonstrated that hungry subjects develop an increase in liking for the flavor of a rapid satiety inducing (high-calorie) food, relative to the flavor of a lower-calorie food.

In the *flavor-flavor association* paradigm, it is predicted that the mere contingent presentation of a neutral flavor or food (CS) with an already liked (or disliked) flavor or food (US), brings about an increase (or decrease) in liking for the originally neutral flavor. This hypothesis is,

at least indirectly, supported by the results of a study by Fanselow and Birk (1982), in which it was observed that after a compound presentation of a neutral flavor with saccharin (or quinine), rats subsequently preferred (or avoided) the originally neutral flavor solution (see also Holman, 1975). The plausibility of flavor-flavor associations as one of the determinants of acquired likes and dislikes for foods is further enhanced by the results of studies on human evaluative conditioning. Namely, using nonfood stimuli, it has repeatedly been demonstrated that the mere contingent presentation of neutral with (dis)liked stimuli is sufficient to change the affective-evaluative tone of the originally neutral stimuli in a (negative) positive direction. This holds for a variety of conditioning preparations, stimulus modalities and parameters of stimulus presentation (for a review, see Baeyens, Eelen, Van den Bergh, & Crombez, 1990b; see also Bierley, McSweeney, & Vannieuwkerk, 1985; Eifert, Craill, Carey, & O'Connor, 1988; Gorn, 1982; Levey & Martin, 1987; Martin & Levey, 1987; Stuart, Shimp, & Engle, 1987). For example, in a recent series of studies by Baeyens *et al.* (1990b), it was shown that subjects develop a liking (or a disliking) for an originally neutral picture of a human face, after contingent presentation of this neutral with a strongly liked (or disliked) picture of a face (Baeyens, Eelen, Crombez, & Van den Bergh, 1988a; Baeyens, Crombez, Van den Bergh, & Eelen, 1988b; Baeyens, Eelen, & Van den Bergh, 1990a; Baeyens, Eelen, Van den Bergh, & Crombez, 1989a, 1989b). Surprisingly however, we know of only one study in which the evaluative conditioning paradigm was applied to study the acquisition of likes and dislikes for food stimuli in humans. In three different experiments, Zellner and collaborators demonstrated that after serving a tea-flavor A several times in compound with a sugar solution, and a tea-flavor B equally often in plain water, there was an enhanced liking for flavor A, even when both flavors were served in unsweetened form (Zellner, Rozin, Aron, & Kulish, 1983). Unfortunately, the flavor-flavor paradigm has never been applied to study the potential acquisition of dislikes for flavors in humans, and neither do we know of any independent replication of the Zellner *et al.* findings. Hence, notwithstanding the intrinsic appeal of the flavor-flavor learning hypothesis, and even though evaluative conditioning research in humans with nonfoods is supportive for the idea, the lack of research efforts prohibits any definite conclusions. In a recent questionnaire study asking for parents' belief in the efficiency of, and actual use of, different methods for inducing food likes/dislikes in their young children, a remarkable parallel was found to this research situation. Namely, even though "mixing a food with a good/bad taste" was *believed* to be highly efficient to modify children's evaluation of the target food, this procedure was rather seldom applied to alter childrens' food likings (Casey & Rozin, 1989).

The first and major purpose of the present study was an attempt to

induce acquired likes and dislikes for flavors in humans, using the flavor-flavor association paradigm. In the CS-FLAVOR conditions, artificial fruit-flavors were used as CSes, and sugar or Tween20 was used as a positive or a negative US, respectively. A differential, simultaneous conditioning paradigm was scheduled, in which each subject would receive one flavor (CS+) in compound with the US (Sugar or Tween20), and another flavor (CS-) in plain water. In the CS-FLAVOR, POSITIVE (Sugar) condition, it was expected that the flavor of the CS+ would become more liked than the flavor of the CS-, whereas in the CS-FLAVOR, NEGATIVE (Tween20) group the reverse was predicted. As only post-treatment evaluative measurements were scheduled, the differential conditioning paradigm used would not allow to assess whether only the CS+, or both the CS+ and the CS- are the targets of evaluative change. Hence, a CS-FLAVOR, CONTROL condition was added, in which subjects received two flavor CSes as in the POSITIVE and NEGATIVE groups, but both CSes were presented in plain water. It was expected that this control condition would provide a baseline, allowing to assess the focus of evaluative change in POSITIVE and NEGATIVE conditions. Finally, in order to mask the crucial CS-US contingencies and to avoid demand-effects as much as possible, both the CS+ and the CS- were presented in four different colors in CS-FLAVOR conditions.

As a second aim of the study, the question was addressed whether or not a perceptual characteristic of a food other than its flavor (i.e., its visual appearance) may also acquire evaluative value when paired with an appetitive or an aversive flavor US. There is ample evidence that, at least in omnivores, exteroceptive sensory characteristics of food are much harder (or not at all) associated with nausea and/or vomiting than flavor characteristics (e.g., Domjan, 1982, 1983; Eelen, Van den Bergh, Baeyens, & Crombez, 1988; Garcia, Ervin, & Koelling, 1966; Garcia & Koelling, 1966; Lolordo & Droungas, 1989). It is not clear, however, whether or not these selective associations also occur when, instead of a nausea-inducing stimulus, liked or disliked flavors are used as the US. The role of selective associations in *humans'* acquisition of food likes/dislikes is even less clear. Of potential relevance however, is the fact that human studies using nonfood stimuli indicate that evaluative learning is possible when CS and US are both of different sensory modalities (e.g., Bierley *et al.*, 1985; Eifert *et al.*, 1988; Gorn, 1982). Visual food characteristic—flavor US associative learning was investigated in the CS-COLOR conditions. In these groups, one color (CS+) was always presented in compound with Sugar (or Tween20), and another color (CS-) was always presented without US. Both CS+ and CS- colors were presented in water solutions with four different flavors, but the flavor of the stimuli was uncorrelated to the compound presentation of

the US. In CS-COLOR as well as in CS-FLAVOR conditions, postconditioning CS+ and CS- evaluations were first obtained for the color and next for the flavor characteristics of the liquids. For obvious reasons, in the CS-FLAVOR groups an evaluative CS+/CS- differentiation was expected only for the flavor-ratings and not for the color-ratings of the stimuli. To the extent conditioning would occur in the CS-COLOR groups, however, an evaluative CS+/CS- differentiation might be expected both for the color and for the flavor ratings of the CSes. Namely, it might well be possible that a food item that (due to conditioning) first looks unattractive also "tastes" bad when next consumed.

The third research question of our study pertained to the relationship between the acquisition of implicit, unverbalizable vs explicit, verbalizable knowledge about the CS-US stimulus relationships. Previous research on evaluative learning has clearly documented that the acquisition of both kinds of knowledge may proceed quite *orthogonally* in human subjects (see Baeyens *et al.*, 1988b, 1989a, 1989b, 1990a). For example, it has been demonstrated that subjects may detect the objectively presented CS-US relationship (as evidenced by evaluative shifts in the CS value, and by postconditioning US revaluation techniques), without acquiring any explicit or conscious knowledge about the CS-US relation [cf. Bowers' (1984) distinction between (unconsciously) *perceiving* and (consciously) *noticing* an entity; see also Lewicki, 1986]. Also, variables have been identified enhancing one but not the other kind of learning (e.g., CS/US perceptual similarity; see Baeyens *et al.*, 1989b). In order to test the generality of this principle, a procedure was used measuring subjects' postconditioning explicit knowledge about the stimulus relationships presented.

Finally, in order to assess the influence of the mere passage of time on the acquired liking or disliking of the food stimuli, the experiment included a 1-week follow-up.

METHOD

Subjects

Seventy-two high-school students (32 males, 40 females), aged 14 through 17, participated voluntarily.¹ They were all uninformed as to the

¹ Six out of the original subgroup of 24 subjects participating in POSITIVE conditions (four females, two males), consistently rated the CS/US (Sugar) compounds as disliked to very disliked stimuli (mean ratings -58, -64, -76, -88, -100, and -100). In their postexperimental comments, these subjects spontaneously expressed to dislike sweet in general, or sweet drinks, or to be on a diet (see also Rozin, 1987). As this represents a failure to administer the correct level of the US-type *independent* variable, it was decided to replace these subjects by six new subjects, who received exactly the same treatment as the replaced subjects. All results in POSITIVE conditions are based on the adjusted subject sample.

purpose of the experiment. They were tested in groups of 6, 9, or 12 subjects. Test duration was about 40 min. At the moment of the follow-up, 1 week after the first participation, 68 subjects were available for retesting.

Stimuli

Four colorless artificial concentrate flavors, Orange, Apricot, Pear, and Raspberry, and four flavorless food colorings, Dark Yellow, Orange, Pink, and Light Yellow², were used as CSes. All CSes were presented in 5 ml water at room temperature. The flavors were presented at a concentration of 2 ml/liter water (Orange and Raspberry) or 1,2 ml/liter water (Pear and Apricot); food colorings were presented at a concentration of 1 ml/liter water. Four percent (40g/liter water) sugar was used as the US in POSITIVE groups. Tween20 (i.e., *polysorbate 20*) was used as the US in NEGATIVE groups, at a concentration of 2 ml/liter water. At these concentrations, both USes (Tween20 and sugar) are colorless and without smell.

In a pilot study ($n = 12$; 6 males and 6 females), all CSes were randomly presented in 5 ml water and evaluated on a $-100/+100$ visual analog rating scale ($-100 =$ very disliked; $0 =$ neutral; $+100 =$ very liked). For the solutions containing food colorants, subjects were invited to express their degree of (dis)liking the color of the drink, for the solutions containing flavors or Tween20/sugar, subjects expressed their degree of (dis)liking the flavor of the drink. Mean and *SD*(mean) obtained for the flavor CSes were: Apricot: -5.1 (14.3); Pear: -9.8 (12.8); Raspberry: $+9.8$ (11.0); Orange: $+6.2$ (10.1). The color CSes were rated: Dark Yellow: $+15.8$ (15.3); Orange: $+28.5$ (12.7); Pink: $+46.3$ (10.2) and Light Yellow $+6.7$ (12.2). Finally, the scores for sugar and Tween20 were $+38.3$ (7.1) and -86.2 (4.7), respectively.

Apparatus

Subjects were tested in the teachers' staff room; the tables were arranged in a square, three sides were occupied by the subjects, one side by the experimenters. Subjects were presented with a tray, on which were placed 24 transparent 30-ml plastic cups, numbered 1 to 24, containing the CS+ and CS- solutions. In addition, to the right of the tray a white boardpaper cup-holder was placed, in which were placed 15 cups (numbers 1 to 15) containing the postconditioning test liquids. Also, to the left of the tray 6 cups were placed to be used for the measurement of subjects' explicit knowledge about stimulus pairings. Finally, within

² Concentrate flavors and food colorings were both obtained at the Central Pharmacological Unit of the University Clinic Saint-Pieter, Catholic University Louvain (Belgium).

easy reach of each subject, the tables contained dishes filled with small pieces of white bread, to be eaten by the subjects between each conditioning trial. At the moment of the followup, subjects were tested in exactly the same setting, except for the tray with the 24 conditioning liquids being absent.

Procedure

The experiment consisted of three sequential phases, a conditioning phase, a postconditioning evaluative response (E.R.) measurement phase, and a phase measuring subjects' explicit knowledge of the stimulus relationships. At the followup, the last two phases were repeated.

Conditioning phase. In the CS-FLAVOR, POSITIVE condition, a 4% sugar solution was used as a positive (liked) US (see also Rozin, 1987). Four artificial fruit flavors (Orange, Apricot, Pear, and Raspberry) were the CSes. The particular two flavors used as CS+ and CS- were completely counterbalanced across subjects ($[N!/(N-n)!] = [4!/(4-2)!] = 12$ possible CS+ /CS- taste combinations within each condition) (see Table 1). Both the CS+ and the CS- were presented in four different colors (Light Yellow, Orange, Pink, Dark Yellow). In the CS-FLAVOR, NEGATIVE condition, Tween20 was used as a harmless but very distasteful (disliked) US, and in the CS-FLAVOR, CONTROL condition, subjects received two flavor CSes both presented in plain (colored) water (Table 1). In the CS-COLOR, POSITIVE group, sugar was used as the US, and four colors (Light Yellow, Orange, Pink, Dark Yellow) were used as CSes. The particular two colors used as CS+ and CS- for each subject were completely counterbalanced across subjects (12 different CS+ /CS- color combinations). Both CS+ and CS- were presented in water solutions with four different flavors (Orange, Apricot, Pear, and Raspberry). In the CS-COLOR, NEGATIVE condition, Tween20 was the US, and in the CS-COLOR, CONTROL condition, both CSes were presented without US (Table 1). Subjects were randomly assigned to one of the six conditions and to one of the 12 possible CS+ /CS- taste or color combinations within each condition [e.g., for CS-FLAVOR, POSITIVE: (CS+, US) = (Orange, Sugar) and CS- = Apricot; for CS-COLOR, NEGATIVE: (CS+, US) = (Pink, Tween20) and CS- = Dark Yellow]. CS-COLOR and CS-FLAVOR conditions were run in different groups, however, and each group consisted of two, three, or four times three subjects receiving the same flavor (or color) CS+ /CS- combination, presented once in a POSITIVE (sugar), once in a NEGATIVE (Tween20), and once in a CONTROL condition (see Table 1).

Upon entering the room, it was explained to the subjects that we were interested in humans' perception of different colors and tastes. The (fe-

TABLE 1
Experimental Design

	Positive (Sugar)		Negative (Tween20)		Control (no US)	
	CS +	CS -	CS +	CS -	CS +	CS -
CS-FLAVOR	Orange ^a Apricot Pear — ^c	Apricot ^a Orange Raspberry —	Orange Apricot Pear —	Apricot Orange Raspberry —	Orange Apricot Pear —	Apricot Orange Raspberry —
CS-COLOR	Pink ^b Dark yellow Orange — ^d	Dark yellow ^b Pink Light yellow —	Pink Dark yellow Orange —	Dark yellow Pink Light yellow —	Pink Dark yellow Orange —	Dark yellow Pink Light yellow —

^a Each flavor presented in four colors ("Variant" variable in analysis of variance).

^b Each color presented with four flavors ("Variant" variable in analysis of variance).

^c Twelve completely counterbalanced CS + /CS - flavor combinations in total.

^d Twelve completely counterbalanced CS + /CS - color combinations in total.

male) experimenter said that they should first look at and consume a series of drinks, and next they should answer some questions about another, similar series of drinks. It was stressed that different people might receive different drinks, so they should not pay too much attention to other subject's reactions to the drinks. Next subjects consumed the 24 CS+ /CS- cups on the tray, containing 12 CS+ and 12 CS- conditioning trials (three instances of CS+ and CS- flavors in each of the four colors in CS-FLAVOR groups; three instances of CS+ and CS- colors in each of the four flavors in COLOR-CS groups). The 24 cups were placed in a semirandomized sequence, in that no more than two consecutive trials were allowed to be a CS+ (or CS-). Each subgroup of three subjects receiving the same CS+ /CS- flavor (or taste) combination, also received the same semirandomized stimulus presentation schedule. Subjects took a solution every 30 s on the (male) experimenter's signal. During the first 5 s of each trial, subjects had to take a cup and look at it, during the next 5 s subjects swirled the solution around in their mouth until the experimenter signaled them to swallow; after another 5 s, subjects took a piece of bread and ate it; the final 15 s of each trial consisted of a waiting phase. The eating of the piece of bread was introduced to avoid after-tastes and the mixing up of flavors of consecutive trials as much as possible.

Evaluative response measurement. The subjects received a response booklet containing two rating scales for each of the 15 stimuli, one for the color and one for the flavor evaluation. The scale was a line 200 mm long, labeled *very disliked* at the left, *neutral* in the middle, and *very liked* at the right. For the color ratings, the terms *very pretty* and *very ugly* were added, for the flavor ratings the terms *very good* and *very bad* were added. The line was divided into 21 categories, labeled by numbers under the scale (-100/-80/-60/. . ./0/. . ./+60/+80/+100). The subject was asked to mark the category indicating her/his evaluation of the color or the flavor of the drinks, respectively. The experimenter strongly stressed the importance of relying on the *first, immediate, and spontaneous* reactions toward the stimuli. As during the conditioning phase, subjects rated a solution every 30 s on the experimenter's signal. During the first 5 s, subjects took a cup, looked at it, and expressed their color-evaluation. During the next 5 s, subjects swirled around the solution and expressed their taste-evaluation; after another 5 s, they consumed a piece of bread and waited for the signal for the next stimulus. The first 10 solutions were the CS+ and CS-, presented without US. In CS-FLAVOR groups, CS+ and CS- flavors were presented once in the four different colors, and once without coloring added. In CS-COLOR groups, CS+ and CS- colors were presented once with each of the four different flavors, and once without flavor. The 10 test-

trials were presented in a semirandomized sequence, in that no more than two consecutive stimuli were allowed to be a CS+ (or a CS-). The final five solutions were CS+ /US compounds, presented in each of the four colors (flavors) and once without color (flavor). These five stimuli were included in order to control for the effectivity of the US used during conditioning.

Measurement of explicit knowledge about stimulus relations. It was explained that some subjects had received sugar in some of their drinks, some subjects a *very bad-tasting substance*, Tween20, and some only fruit flavors. Subjects who participated in POSITIVE or NEGATIVE conditions received a response sheet, on which they could indicate their explicit beliefs about the stimulus relationships presented during the conditioning phase. Subjects were invited to answer two questions: (1) Sugar (or Tween) most of the time was presented together with (a) flavor (or color) CS+ /flavor (or color) CS- /Dark Yellow/Orange/Pink/Light Yellow (or Orange/Pear/Raspberry/Apricot); (b) Sugar (or Tween) was not presented consistently with something else, and (2) I am completely sure/rather sure/rather unsure/completely unsure of my answer on the first question. To avoid confusions related to the labeling of the flavor stimuli, flavor solutions were placed in front of the subjects; in addition, under each cup containing a flavor a piece of paper was placed, on the back of which the name of the flavor was written. Color solutions were also present.

Followup. Evaluative response measurements and the measurement of subjects' explicit knowledge of stimulus relationships were both repeated 1 week after subjects' first participation.

RESULTS

CS/US-Compound Flavor Ratings

Mean flavor ratings for the POSITIVE, NEGATIVE, and CONTROL CS/US compound stimuli were 29.59, -67.92, and -35.92, respectively (37.85, -69.85, and -45.40 in CS-FLAVOR groups; 21.32, -65.98, and -26.43 in CS-COLOR groups).¹ At the followup, POSITIVE, NEGATIVE, and CONTROL CS/US compounds were rated 32.25, -67.59, and -15.79, respectively (39.70, -66.80, and -3.98 in CS-FLAVOR groups; 24.80, -68.38 and -27.60 in CS-COLOR groups).

Cs Flavor Ratings: Data Transformation and Analysis

As represented in the left section of Table 2, the within-group (i.e., within POSITIVE, NEGATIVE, and CONTROL conditions) CS+ and CS- flavor ratings discriminated in the expected direction, but more so in CS-FLAVOR than in CS-COLOR conditions. However, a comparison

TABLE 2
CS Flavor Ratings—Main Experiment

CS Type	US Type	CS+	CS-	$d = [(CS+) - (CS-)]$	$z(CS+)$	$z(CS-)$	F
CS-FLAVOR	Positive	-22.18	-29.52	7.24	0.10	-0.10	1.26
	Negative	-22.18	4.60	-26.78	-0.34	0.34	15.00*
	Control	-35.13	-33.85	-1.28	-0.02	0.02	0.03
CS-COLOR	Positive	-27.63	-30.08	2.45	0.03	-0.03	0.11
	Negative	-11.50	-5.63	-5.87	-0.08	0.08	0.74
	Control	-16.06	-17.10	1.04	0.01	-0.01	0.03

* $p < .003$ (each test at .0005; $df^* = 1,66$).

of CS + (and CS -) ratings *between* POSITIVE, NEGATIVE, and CONTROL conditions seemed to indicate that, if anything, it was *the* CS - rather than the CS + which was the focus of evaluative change.³ For example, even though the CS + was rated more positively than the CS - in the CS-FLAVOR, POSITIVE condition (difference = +7.24), and more negatively than the CS - in the NEGATIVE, CS-FLAVOR condition (difference = -26.78), both CS +es obtained exactly the same evaluative ratings. Also, both in the CS-FLAVOR and in the CS-COLOR conditions, the overall CS flavor ratings seemed more negative in CONTROL conditions than in NEGATIVE (Tween) conditions.³ The position advanced here, however, maintains that these at first sight striking phenomena should be attributed to a *differential anchoring* of evaluative- (real degree of (dis)liking), stimulus- (CSes and USes) and response- (-100/+100 visual analog rating scale) continua, in POSITIVE, NEGATIVE, or CONTROL conditions. For example, subjects in NEGATIVE conditions probably rated—objectively equally valued—neutral stimuli (CSes) overall more positively than subjects in POSITIVE or CONTROL conditions, *due to the presence and rating of a strongly negative flavor stimulus*, Tween20, in the former but not in the latter groups' stimulus set (see Risky, Parducci, & Beauchamp, 1979; Rozin, 1984; Sandusky & Parducci, 1965; Upshaw & Ostrom, 1984, for further arguments on the determination of evaluative judgments (ratings) by stimulus range or context). If this is what happened, it must be acknowledged that comparing the absolute value of the raw CS flavor ratings *between* POSITIVE, NEGATIVE, and CONTROL groups, is meaningless. Comparisons are possible, however, after standardization (*z transformation*) of each subgroup's ratings separately (i.e., based on the means and the standard deviations of the ratings of CS-FLAVOR, POSITIVE; CS-FLAVOR, NEGATIVE; CS-FLAVOR, CONTROL; CS-COLOR, POSITIVE; CS-COLOR, NEGATIVE; CS-COLOR, CONTROL groups separately). The results of this *z transformation* are represented in Table 2, middle section (see also Fig. 1). Subsequent analyses of the flavor ratings were performed on these *z scores*.

³ A CS-type $\times$ US-type $\times$ Conditioning $\times$ Variant analysis of variance on raw data (i.e., before *z transformation*) revealed exactly the same effects as the analysis on *z scores*, except for an additional main effect of the US-type variable [$F(2, 44) = 4.10$; $p < 0.025$; mean flavor ratings in POSITIVE, NEGATIVE, and CONTROL conditions were -27.35, -8.68, and -25.54, respectively]. Also, the Conditioning $\times$ US-type interaction [$F(2, 44) = 6.61$; $p < 0.005$] implied a significant US-type effect *at the CS -* [$F(2, 88) = 7.27$; $p < 0.01$] but not at the CS + level [$F(2, 88) < 1$] (both tests at $p < 0.005$). Both the main effect of US-type and the significant effect of the US-type for CS-es and not for the CS +es, were ascribed to the supposed differential anchoring phenomenon, and disappeared due to the *z transformation* of the data.

FIG. 1. Mean CS + and CS - flavor ratings (z scores), in CS-FLAVOR and CS-COLOR groups. Data from POSITIVE, NEGATIVE, and CONTROL conditions.

Transformed flavor ratings were analyzed by means of a $2 \times 3 \times 2 \times 5$ analysis of variance (CS-type (CS-FLAVOR/CS-COLOR) $\times$ US-type (POSITIVE/NEGATIVE/CONTROL) $\times$ Conditioning (CS+/CS-) $\times$ Variant (V1/V2/V3/V4/V5)), with CS-type as a between group variable and Conditioning and Variant as repeated measures variables. The US-type variable was also treated as a within-subject variable, with three subjects having received the same CS+/CS- flavor (or color) combination in the same semirandomized presentation sequence (but either participating in POSITIVE, NEGATIVE, or CONTROL conditions), representing one single block of data. The Variant variable refers to the CS evaluative measurements obtained under different coloring conditions (CS-FLAVOR groups) or different flavor conditions (CS-COLOR groups) (e.g., with Apricot flavor as CS+ and Raspberry flavor as CS-, the Apricot flavor ratings obtained when Apricot flavor was presented in Dark Yellow, Orange, Pink, Light Yellow, or without food coloring, represent five levels of the Variant variable).

Quite unexpectedly, a (difficult to interpret) main effect was obtained for the Variant variable [$F(4, 88) = 4.33$; $p < 0.005$]. Of crucial importance, however, a significant interaction between Conditioning $\times$ US-type variables was observed [$F(2, 44) = 6.49$; $p < 0.005$]. This interaction was due to the fact that in POSITIVE conditions, CS+ evaluations (mean $z = 0.07$) were more positive than CS- evaluations (mean $z = -0.07$), but not significantly so [$F(1, 66) = 1.06$; ns]; in NEGATIVE conditions,

CS+ evaluations (mean $z = -0.21$) were significantly lower than CS- evaluations (mean $z = 0.21$) [$F(1, 66) = 11.20$; $p < 0.003$]; in CONTROL conditions, no CS+/CS- differentiation was observed [mean z CS+ = 0.00; mean z CS- = 0.00; $F(1, 66) < 1$] (each hypothesis tested at $p < 0.001$). Even though the second-order interaction CS-type $\times$ US-type $\times$ Conditioning only reached borderline significance [$F(2, 44) = 2.36$; $p < 0.11$], a more detailed analysis of this interaction demonstrated a clear US-type $\times$ Conditioning interaction at the CS-FLAVOR level of the CS-type variable [$F(2, 44) = 8.33$; $p < 0.002$], but no evidence of such an interaction at the CS-COLOR level [$F(2, 44) < 1$] (see Fig. 1). No other interactions were significant. The Conditioning effect was further analyzed at each level of the CS-type $\times$ Conditioning variables. As represented in Table 2 (right section), in CS-FLAVOR conditions the CS+/CS- flavor differentiation was in the expected direction at all levels of the US-type variable, but only in the NEGATIVE condition a significant conditioned CS+/CS- discrimination was observed. In CS-COLOR conditions none of the CS+/CS- differentiations was significant, although all being in the expected direction (see Fig. 1). Hence, a differential conditioning effect was only apparent with flavor-CSes, and only when a negative US (i.e., Tween20) was used.

The conclusion that no differential conditioning was obtained in the CS-FLAVOR, POSITIVE condition is, however, modified by the following observation. Even though the mean CS+/US compound flavor rating was positive (mean = +37.9) in this subgroup, subjects demonstrated considerable variability in their CS+/US compound ratings (range from +2 up to +74; $SD = 22.3$). On the other hand, a Pearson r between each subject's mean CS+/US rating and mean CS+/CS- discrimination, $d = [(\text{mean CS+}) - (\text{mean CS-})]$, was 0.54 ($p < 0.05$). This indicates that the more effective the sugar-US was in evoking strong liking responses, the stronger was the CS+/CS- discrimination or conditioning.

CS Color Ratings

Mean CS+/CS- color ratings obtained in each condition are represented in Table 3. The (raw)⁴ ratings of subjects' liking of the *color* of the CSes were analyzed by means of a $2 \times 3 \times 2 \times 5$ (CS-type $\times$ US-type $\times$ Conditioning $\times$ Variant) analysis of variance. No evidence for a conditioning effect was obtained, in that none of the interactions involving Conditioning $\times$ US-type reached significance. Of particular im-

⁴ As subjects in POSITIVE, NEGATIVE, and CONTROL conditions were exposed to the same set of color stimuli, the differential anchoring issue was irrelevant to the color ratings. Consequently, no z transformation was applied to the color ratings.

TABLE 3
CS Color Ratings—Main Experiment

CS Type	US Type	CS +	CS -	$d = [(CS+) - (CS-)]$
CS-FLAVOR	Positive	12.61	19.75	-7.13
	Negative	15.10	18.55	-3.45
	Control	8.95	7.25	1.70
CS-COLOR	Positive	-6.60	4.90	-11.50
	Negative	-1.00	4.23	-5.23
	Control	4.17	1.28	2.88

portance, there was not the slightest evidence for the crucial Conditioning $\times$ US-type interaction in the CS-COLOR groups [$F(2, 44) < 1$].

Of less importance for our research question, both the CS-type variable [$F(1, 22) = 5.39$; $p < .025$], the Variant variable [$F(4, 88) = 5.53$; $p < 0.001$], and their interaction [$F(4, 88) = 5.48$; $p < 0.001$] were significant. The effect of the CS-type variable implied overall more favorable color ratings in the CS-FLAVOR conditions (mean = 13.70) than in the CS-COLOR conditions (mean = 1.2). Quite probably, this may be due to the fact that subjects in the CS-FLAVOR groups were exposed to five different food colorings, producing more variety and less boredom than the two different colors to which CS-Color subjects were exposed. The Variant $\times$ CS-type interaction was due to a significant Variant effect in CS-Taste [$F(4, 88) = 10.94$; $p < .001$], but not in CS-Color groups [$F(4, 88) < 1$] (each test at $p < 0.0005$). That is, different colors evoked different degrees of liking (Dark Yellow = 7.9; Light Yellow = -11.1; Orange = 23.8; Pink = 38.1; colorless = 2.7) (CS-FLAVOR conditions), but evidently, adding different flavors to food colorings does not affect the ratings of these colors (CS-COLOR conditions).

Explicit Knowledge about Stimulus Relationships

Subjects' responses were classified in one of three categories: correct identification of the CS+ (correct); identification of an irrelevant stimulus feature (e.g., a color in CS-FLAVOR groups) as the CS+ (error, irrelevant); statement that the US did not covary systematically with any stimulus feature (error, unsystematic). As represented in Table 4, *none* of the subjects in the CS-FLAVOR conditions correctly identified the CS+ used during conditioning, whereas 11 out of 24 subjects in the CS-COLOR conditions explicitly knew which stimulus had been presented contingently with the US. A test of independence confirmed the influence of the CS-type variable (FLAVOR or COLOR) on subjects' responses (correct/error, irrelevant feature/error, unsystematic) [$\chi^2(2) = 14.44$; $p < 0.001$]. On the other hand, the frequency of correct, error, irrelevant,

TABLE 4
Explicit Knowledge about Stimulus Relationships

		Grouping	Correct	Error, irrelevant	Error, unsystematic
Main exp.	(<i>n</i> = 24)	CS-FLAVOR	0	11	13
	(<i>n</i> = 24)	CS-COLOR	11	5	8
	(<i>n</i> = 24)	Positive	7	5	12
	(<i>n</i> = 24)	Negative	4	11	9
Follow-up	(<i>n</i> = 20)	CS-FLAVOR	0	7	13
	(<i>n</i> = 24)	CS-COLOR	12	2	10
	(<i>n</i> = 22)	Positive	7	4	11
	(<i>n</i> = 22)	Negative	5	5	12

or error, unsystematic answers was not influenced by the US-type (POSITIVE or NEGATIVE) [$\chi^2(2) = 3.50$; ns]. Finally, subjects expressed about equal confidence levels about their answers in all conditions (mean CS-FLAVOR, POSITIVE = 2.33; CS-FLAVOR, NEGATIVE = 2.67; CS-COLOR, POSITIVE = 2.08; CS-COLOR, NEGATIVE = 2.33, with completely unsure = 1; rather unsure = 2; rather sure = 3; completely sure = 4).

Followup CS Flavor and Color Ratings

At the moment of the followup, four subjects were unavailable for retesting, resulting in the loss of two blocks of data in the CS-FLAVOR condition. Subsequent analyses were performed on this reduced dataset. The flavor ratings obtained at the followup were first transformed to *z* scores (per subgroup), and next analyzed by means of a $2 \times 3 \times 2 \times 5$ (CS-type $\times$ US-type $\times$ Conditioning $\times$ Variant) analysis of variance. The interaction between Conditioning $\times$ US-type variables reached (borderline) significance [$F(2, 40) = 3.17$; $p < 0.055$], and implied no Conditioning effect in POSITIVE conditions [mean *z* CS+ = 0.10; mean *z* CS- = -0.10; $F(1, 60) = 2.18$; ns], neither in CONTROL conditions [mean *z* CS+ = 0.08; mean *z* CS- = -0.08; $F(1, 60) = 1.62$; ns], but a significant effect in NEGATIVE conditions (mean *z* CS+ = -0.14; mean *z* CS- = 0.14; [$F(1, 60) = 4.30$; $p < 0.05$] (each test at $p < 0.05$). When the Conditioning $\times$ US-type interaction was tested separately for CS-FLAVOR and CS-COLOR conditions, only in the CS-FLAVOR condition borderline significance was obtained [$F(2, 40) = 2.65$; $p < 0.09$; $F(2, 40) < 1$, respectively]). No other interactions nor main effects were observed, except for the difficult to interpret effect of the Variant variable [$F(4, 80) = 9.91$; $p < .005$]. Hence, even though the general pattern of the followup flavor ratings paralleled the results

obtained immediately after conditioning, only a weak residual NEGATIVE conditioning effect was still present.

The followup CS color ratings were analyzed in the same way as the color ratings obtained immediately after conditioning. A $2 \times 3 \times 2 \times 5$ analysis of variance demonstrated a significant Variant effect [$F(4, 80) = 3.24$; $p < .025$], and a significant Variant $\times$ CS-type interaction [$F(4, 40) = 3.37$; $p < 0.025$]. Again, this interaction was due to a significant Variant effect in CS-FLAVOR conditions [$F(4, 80) = 6.53$; $p < .001$] and the absence of such an effect in CS-COLOR conditions [$F(4, 80) < 1$] (both tests at $p < .0005$).

Followup Explicit Knowledge about Stimulus Relations

One week after the main experiment, subjects' explicit knowledge about the stimulus relations remained essentially unaltered (see Table 4). Again, in CS-FLAVOR groups none of the subjects correctly identified the CS+, but 12 out of 24 subjects did so in CS-COLOR groups. The CS-type variable clearly influenced the frequency of correct, error, irrelevant, and error, unsystematic answers [$\chi^2(2) = 14.93$; $p < 0.001$]. These answers were not influenced however by the US-type variable [$\chi^2(2) = 0.49$; ns].

DISCUSSION

In this study, first it was demonstrated that Pavlovian flavor-flavor associations do occur in human subjects. After 12 contingent presentations of a particular neutral flavor with a distasteful substance, subjects clearly evidenced an evaluative discrimination between this originally neutral flavor and another flavor which was never experienced in compound with the aversive US. Moreover, 1 week after the experimental manipulation, a residual negative conditioning effect was still apparent. Second, no convincing evidence was found for a positive conditioning effect, i.e., for flavor-sugar evaluative conditioning. Third, the contingent presentation of a visual food characteristic (color) with a flavor US did not result in any conditioning effect: After the conditioning phase, subjects showed no evaluative discrimination, nor between the color, and neither between the flavor of fluids containing either the CS+ food-coloring or the CS- coloring. Fourth, none of the subjects in the CS-FLAVOR groups evidenced any explicit knowledge about the stimulus relationships presented during conditioning, whereas about half of the subjects in CS-COLOR groups did so.

The Difference between Positive (Sugar) and Negative (Tween)

Learning Results

The following observations deserve attention in the interpretation of the discrepancy between negative (Tween20) and positive (Sugar) con-

ditioning results. First, the positive US (pilot study) and the CS/positive-US compound (experiment) were not quite liked as much as the negative US and the CS/negative-US compounds were disliked. Hence, US-intensity differences may be responsible for the observed difference between positive and negative learning. Second, even though no significant CS+/CS- was observed in POSITIVE conditions, CS+ and CS- ratings were clearly in the expected direction. Third, it was observed that subjects demonstrated considerable variability in their liking of the CS+/Sugar compounds, while the extent of CS+/CS- discriminations correlated positively with the degree of subjects' CS+/Sugar compound liking. This is clearly suggestive for the possibility that positive flavor-flavor associations might have been observed, when the sugar-US would have been equally liked by all subjects, as Tween20 was disliked.

Alternatively, the positive/negative discrepancy might be considered to be an instance of the well-documented (affective) *positive-negative asymmetry*. That is, negative events often have more affective impact than equally intense positive events (Peeters & Czapinski, 1989). In this case, this might imply that humans (and other omnivores) are predisposed to learn more rapidly or easily about the correlates of negative than of positive events (see Rozin, 1984, 1986; Zahorik, 1979, e.g., for further evidence and discussion of a negative learning bias). At present, it seems premature to favor one or another of these two alternative interpretations.

Finally, it is not clear at present why flavor-sugar associations could be demonstrated in Zellner *et al.*'s (1983) study and not in ours. The difference in the number of acquisition trials in both studies (24 in Zellner's vs 12 in the present study) is one plausible explanatory candidate. Also, there are a number of other procedural differences that could be involved. For example, whereas we only used one sugar concentration (4%), Zellner *et al.* exposed their subjects to a combination of 2, 4, 6, and 8% sugar concentrations (in two out of the three experiments). Whereas our procedure required subjects just to look at and consume the stimuli during acquisition, Zellner *et al.* asked their subjects to rate the sweetness (two experiments) or the bitterness (one experiment) of the stimuli at each of the acquisition trials. Quite speculatively, a differential effectivity of sugar as a positive US in both subject samples, might be thought of as still another possible explanation. Indeed, there are some arguments that socio-cultural variables can transform (innately positive) sugar into a "sinful," "unsafe," or at least ambivalent stimulus for some subjects (Rozin, 1987).

The Target of Evaluative Change

As explained in the introductory section, a CONTROL condition was scheduled to determine whether the CS+, or both the CS+ and CS- were the focus of evaluative change in POSITIVE and NEGATIVE

conditions. We had to admit, however, that between-group comparisons of raw data are complicated by a differential anchoring phenomenon. Hence, no conclusions could be made concerning the focus of evaluative change. In future research, the differential anchoring of evaluative and response continua might be (partially) avoided, by pre-exposing all subjects at least once to all stimuli used in all between-conditions.

Selective Associations

The fact that we did find evidence for flavor-flavor but not for color-flavor evaluative conditioning, *may* indicate that selective associations do occur in humans' acquisition of food likes and dislikes (see the introductory section). A similar position has been defended by Logue *et al.* (1981), who observed in a questionnaire study that the taste of food items was the (or a) focus of evaluative change in 83% of all of the reported illness-induced food aversions, whereas the visual appearance of the food became aversive in only 26% of all cases. Further research is needed, however, to rule out the alternative possibility, that specific characteristics of the CSes used in this study are responsible for the difference in conditioning results, instead of qualitative characteristics of the CS-US *relationship* (see Baeyens *et al.*, 1989b). An experimental design comparing the effectiveness of flavor/flavor, visual-characteristic/flavor, flavor/visual-characteristic, and visual-characteristic/visual-characteristic CS/US pairings could further clarify this issue.

Dissociation of Affective Learning and the Acquisition of Explicit Knowledge about Stimulus Contingencies

A double dissociation was observed between evaluative learning and the acquisition of explicit knowledge, in that subjects in CS-FLAVOR groups demonstrated evaluative conditioning but no acquisition of explicit knowledge about stimulus relations, and subjects in CS-COLOR groups failed to demonstrate conditioning effects but explicitly knew which stimulus feature was correlated with the US presentation. The finding that explicit knowledge is no prerequisite for evaluative learning, replicates previous results from our laboratory (e.g., Baeyens *et al.*, 1990b), and supplies additional evidence for the idea of implicit learning (cf. Lewicki, 1986; Reber, 1989) in humans. The absence of evaluative conditioning in the CS-COLOR groups, in spite of the fact that about half of the subjects clearly acquired explicit knowledge about the stimulus relations, may be interpreted in either of two ways. One possibility would be that the acquisition of explicit knowledge inhibits evaluative conditioning. The alternative proposed here is that the two kinds of learning proceed *orthogonally* to each other. That is, due to the exposure to one and the same set of stimulus covariations, either implicit (as evidenced by the evaluative shifts), or explicit (as evidenced by responses on the

postconditioning questionnaire), or both kinds of knowledge may develop without any mutual influence (see also Baeyens *et al.*, 1989b, 1990b; Campbell, Deutsch Capaldi, Sheffer, & Bradford, 1988; Lewicki, 1986; Marcel, 1983; Reber, 1989).

Finally, for those interested in the origins of human food likes and dislikes, these results clearly demonstrate that Pavlovian flavor-flavor associations may be operative as determinants of human food likes and dislikes. As the systematic combination of different flavors is the rule rather than the exception in human food practice (Rozin, 1983), it could be expected that the opportunities for flavor-flavor conditioning in humans are manifold. For the students of the origins of human evaluative value, the present findings extend and corroborate previous research on evaluative conditioning. It does so in extending the scope of evaluative conditioning phenomena to the gustatory-olfactory sensory modality, and in demonstrating that evaluative conditioning is also operative when a feature of a stimulus compound rather than the total stimulus complex entertains a contingent relationship with a valued event.

REFERENCES

- Arwas, S., Rolnick, A., & Lubow, R. E. (1989). Conditioned taste aversions in humans using motion-induced sickness as the US. *Behaviour Research and Therapy*, *27*, 295–301.
- Baeyens, F., Eelen, P., Crombez, G., & Van den Bergh, O. (1988a). Weten dat en houden van: Signaal-leren in confrontatie met affectief-evaluatief leren. *Gedragstherapie*, *21*, 197–216.
- Baeyens, F., Crombez, G., Van den Bergh, O., & Eelen, P. (1988b). Once in contact always in contact: Evaluative conditioning is resistant to extinction. *Advances in Behaviour Research and Therapy*, *10*, 179–199.
- Baeyens, F., Eelen, P., Van den Bergh, O., & Crombez, G. (1989a). Acquired affective-evaluative value: Conservative but not unchangeable. *Behaviour Research and Therapy*, *27*, 279–287.
- Baeyens, F., Eelen, P., Van den Bergh, O., & Crombez, G. (1989b). The influence of CS-US perceptual similarity/dissimilarity on human evaluative learning and signal learning. *Learning and Motivation*, *20*, 322–333.
- Baeyens, F., Eelen, P., & Van den Bergh, O. (1990a). Contingency awareness in evaluative conditioning: A case for unaware affective-evaluative learning. *Cognition and Emotion*, *4*, 3–18.
- Baeyens, F., Eelen, P., Van den Bergh, O., & Crombez, G. (1990b). *The representation of acquired evaluative value: Intrinsic or implicitly referential?* Submitted for publication.
- Bernstein, I. L., & Webster, M. M. (1980). Learned taste aversions in humans. *Physiology and Behaviour*, *25*, 363–366.
- Bierley, C., McSweeney, F. K., & Vannieuwkerk, R. (1985). Classical conditioning of preferences for stimuli. *Journal of Consumer Research*, *12*, 316–323.
- Birch, L. L. (1986). Children's food preferences: Developmental patterns and environmental influences. In C. Whitehurst & R. Vastha (Eds.), *Annals of child development* (Vol. 4). Greenwich, CT: JAI Press.
- Booth, D. A., Mather, P., & Fuller, J. (1982). Starch content of ordinary foods associatively

- conditions human appetite and satiation, indexed by intake and eating pleasantness of starch-paired flavors. *Appetite*, **3**, 163–184.
- Bowers, K. S. (1984). On being unconsciously influenced and informed. In K. S. Bowers & D. Meichenbaum (Eds.), *The unconscious reconsidered* (pp. 227–272). New York: John Wiley and Sons.
- Campbell, D. H., Deutsch Capaldi, E., Sheffer, J. D., & Bradford, J. P. (1988). An examination of the relationship between expectancy learning and preference conditioning. *Learning and Motivation*, **19**, 162–182.
- Casey, R., & Rozin, P. (1989). Changing children's food preferences: Parent opinions. *Appetite*, **12**, 171–182.
- Domjan, M. (1982). Selective associations in aversion learning. In M. L. Commons, R. J. Herrnstein, & A. R. Wagner (Eds.), *Quantitative analysis of behavior: III Acquisition* (pp. 257–272). Cambridge, MA: Ballinger.
- Domjan, M. (1983). Biological constraints on instrumental and classical conditioning 10 years later: Implications for general process theory. In G. Bower (Ed.), *Psychology of learning and motivation*. (Vol. 17). New York: Academic Press.
- Eelen, P., Van den Bergh, O., Baeyens, F., & Crombez, G. (1988). Leerpsychologie en gedragstherapie. In H. Orlemans, W. Haayman, & P. Eelen (Eds.), *Handboek voor Gedragstherapie* (Vol. 4). Deventer: Van Loghum Slaterus.
- Eifert, G. H., Craill, L., Carey, E., & O'Connor, C. (1988). Affect modification through evaluative conditioning with music. *Behaviour Research and Therapy*, **26**, 321–330.
- Fanselow, M. S., & Birk, J. (1982). Flavor-flavor associations induce hedonic shifts in taste preference. *Animal Learning and Behavior*, **10**, 223–228.
- Garcia, J., Ervin, F. R., & Koelling, R. A. (1966). Learning with prolonged delay of reinforcement. *Psychonomic Science*, **5**, 121–122.
- Garcia, J., & Koelling, R. A. (1966). Relation of cue to consequence in avoidance learning. *Psychonomic Science*, **4**, 123–124.
- Gorn, G. J. (1982). The effects of music in advertising on choice behavior: A classical conditioning approach. *Journal of Marketing*, **46**, 94–101.
- Holman, E. W. (1975). Immediate and delayed reinforcers for flavor preferences in rats. *Learning and Motivation*, **6**, 91–100.
- Levey, A. B., & Martin, I. (1987). Evaluative conditioning: A case for hedonic transfer. In H. J. Eysenck & I. Martin (Eds.), *Theoretical foundations of behavior therapy*. New York: Plenum Press.
- Lewicki, P. (1986). *Nonconscious social information processing*. New York: Academic Press.
- Logue, A. W., Ophir, I., & Strauss, K. E. (1981). The acquisition of taste aversions in humans. *Behaviour Research and Therapy*, **19**, 319–333.
- Lolordo, V. M., & Droungas, A. (1989). Selective associations and adaptive specializations: Taste aversions and phobias. In S. Klein & R. Mowrer (Eds.), *Contemporary learning theories: Instrumental conditioning theory and impact of biological constraints on learning*. Hillsdale, NJ: Erlbaum.
- Marcel, J. (1983). Conscious and unconscious perception: An approach to the relation between phenomenal experience and perceptual processes. *Cognitive Psychology*, **15**, 238–300.
- Martin, I., & Levey, A. B. (1987). Learning what will happen next: Conditioning, evaluation and cognitive processes. In G. Davey (Ed.), *Cognitive processes and Pavlovian conditioning in humans*, (pp. 57–82). New York: Wiley & Sons.
- Peeters, G., & Czapinski, J. (1989). Positive-negative asymmetry in evaluations: The distinction between affective and informational negativity effects. In W. Stroebe & M. Hewstone (Eds.), *European review of social psychology*. Chichester: Wiley.

- Pelchat, M. L., & Rozin, P. (1982). The special role of nausea in the acquisition of food dislikes by humans. *Appetite*, 3, 341–351.
- Reber, A. S. (1989). Implicit learning and tacit knowledge. *Journal of Experimental Psychology: General*, 118, 219–235.
- Riskey, D. R., Parducci, A., & Beauchamp, G. K. (1979). Effects of context in judgements of sweetness and pleasantness. *Perception and Psychophysics*, 26, 171–176.
- Rozin, E. (1983). *Ethnic cuisine: The flavor principle cookbook*. Brattleboro, VT: Stephen Green Press.
- Rozin, P. (1984). The acquisition of food habits and preferences. In J. D. Matarazzo, S. M. Weiss, J. A. Herd, N. E. Miller, & S. M. Weiss (Eds.), *Behavioral health: A handbook of health enhancement and disease prevention* (pp. 590–607). New York: John Wiley and Sons.
- Rozin, P. (1986). One-trial acquired likes and dislikes in humans: Disgust as a US, food predominance, and negative learning predominance. *Learning and Motivation*, 17, 180–189.
- Rozin, P. (1987). Sweetness, sensuality, sin, safety and socialization: Some speculations. In J. Dobbing (Ed.), *Sweetness*. London: Springer-Verlag.
- Rozin, P. (1988). Social learning about food by humans. In T. R. Zentall & B. G. Galef (Eds.), *Social learning: Psychological and biological perspectives* (pp. 165–187). Hillsdale, NJ: Erlbaum.
- Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review*, 94, 23–41.
- Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annual Review of Nutrition*, 6, 433–456.
- Rozin, P., & Zellner, D. (1985). The role of Pavlovian conditioning in the acquisition of food likes and dislikes. In N. S. Braveman & P. Bronstein (Eds.), *Experimental assessments and clinical applications of conditioned food aversions* (pp. 189–202). New York: New York Academy of Sciences.
- Sandusky, A., & Parducci, A. (1965). Pleasantness of odors as a function of the immediate stimulus context. *Psychonomic Science*, 3, 321–322.
- Stuart, E. W., Shimp, T. A., & Engle, R. W. (1987). Classical conditioning of consumer attitudes: Four experiments in an advertising context. *Journal of Consumer Research*, 14, 334–349.
- Upshaw, H. S., & Ostrom, M. (1984). Psychological perspective in attitude research. In J. R. Eiser (Ed.), *Attitudinal judgement*. New York: Springer-Verlag.
- Van den Bergh, O., Van Huyck, C., Eelen, P., & Baeyens, F. (1989). Geconditioneerde misselijkheid en braken bij kankerpatiënten ten gevolge van chemotherapie. *Gedrag en Gezondheid*, 16, 149–158.
- Zahorik, D. (1979). Learned changes in preferences for chemical stimuli: Asymmetrical effects of positive and negative consequences, and species differences in learning. In J. H. A. Kroeze (Ed.), *Preference behaviour and chemoreception* (pp. 233–246). London: Information Retrieval.
- Zellner, D. A., Rozin, P., Aron, M., & Kulish, C. (1983). Conditioned enhancement of human's liking for flavor by pairing with sweetness. *Learning and Motivation*, 14, 338–350.

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