

# Associative Learning of Likes and Dislikes: A Review of 25 Years of Research on Human Evaluative Conditioning

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Evaluative conditioning refers to changes in the liking of a stimulus that are due to the fact that the stimulus has been paired with other, positive or negative stimuli. Although evaluative conditioning appears to be subjected to certain boundary conditions, significant evaluative conditioning effects have been obtained using a large variety of stimuli and procedures. Some data suggest that evaluative conditioning can occur under conditions that do not support other forms of Pavlovian conditioning, and several models have been proposed to account for these differences. In the present article, the authors summarize the available literature, draw conclusions where possible, and provide suggestions for future research.

Scholars of learning psychology (e.g., Martin & Levey, 1978), social psychology (e.g., Zajonc, 1980), consumer science (e.g., Stuart, Shimp, & Engle, 1987), emotion research (e.g., Sherer, 1993), and clinical psychology (e.g., Hermans, 1998) have all pointed to the important role that preferences play in determining human behavior. For instance, people tend to approach the objects they like but reject or avoid disliked objects. Because virtually all objects or events can be endowed with a certain valence (Osgood, Suci, & Tannenbaum, 1957), preferences influence many aspects of our life, including social interactions and the consumption of goods. Moreover, most emotion researchers agree that emotions are tightly linked to preferences. Most often, if not always, emotions come about only when certain valenced objects or events are involved (Lazarus, 1991; Sherer, 1993). Given the pervasive impact that preferences have on a wide range of behaviors, it is vital to understand how our likes and dislikes are formed.

Empirical evidence suggests that the majority of likes and dislikes are learned rather than innate (Rozin & Millman, 1987). Until recently, however, the nature of the underlying mechanism and processes behind the development of likes and dislikes has been relatively neglected. In the present article, we review evidence that relates to the acquisition of liking through associative learning or conditioning. This associative transfer of valence is commonly referred to as *evaluative conditioning* (EC). EC refers to changes in the liking of a stimulus that result from pairing that stimulus with other positive or negative stimuli.

At a procedural level, EC can be regarded as a form of *Pavlovian conditioning* (PC). In the traditional PC paradigm, a condi-

tioned stimulus (CS), such as a light, is paired with an unconditioned stimulus (US), such as the presentation of a shock or food, to explore whether appetitive or defensive preparatory responses to the CS change as a result of these pairings. In EC studies, a neutral stimulus is paired with an affective stimulus, and changes in the valence of the neutral stimulus are measured. Thus the neutral stimulus is equivalent to the CS, and the affective stimulus to the US. However, it is important to make a distinction between the procedural and process levels (Eelen, 1980). Although EC and other forms of PC are very similar procedurally, it might be the case that the underlying processes differ in fundamental ways. We return to this theme later in the review.

Modern research on EC was inspired by the work of Levey and Martin (1975). Nevertheless, there have been earlier demonstrations of the phenomenon. Razran (1954) devised the so-called luncheon technique. In this paradigm, participants were initially asked to rate a range of stimulus materials including music, literary quotations, photographs, paintings, and political slogans. Next, participants were presented with the political slogans a second time, either in the context of a free lunch or while exposed to unpleasant odors. Razran found that the slogans paired with the free lunch were subsequently rated more positively than those associated with the aversive odors. As such, the pairing of a CS (a political slogan) with either a positive (free lunch) or negative (unpleasant odor) US changed the liking of the CS. Although couched in different theoretical concepts, findings from the verbal conditioning paradigm developed by Staats and Staats (1957) also provide early evidence of EC. Staats and Staats demonstrated that nonsense words paired with either positively or negatively valenced words acquired the same affective value of the words with which they were paired (see Jaanus, Defares, & Zwaan, 1990, for a review).

Since these early demonstrations of EC, the phenomenon has been studied by a variety of researchers from backgrounds as diverse as consumer science (e.g., Stuart et al., 1987), social psychology (e.g., Olson & Fazio, in press), and learning psychology (e.g., Baeyens, 1998; Martin & Levey, 1978). In this review,

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Frank Baeyens was supported by a scholarship from the Fund for Scientific Research, Flanders, Belgium.

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we bring together the research conducted in these different areas. Our aim is to provide the reader with a comprehensive guide to the literature on EC. In the first section of this review, we focus on the generality of EC by describing the different stimuli and paradigms that have been used and the procedural parameters that influence the phenomenon. We also pay attention to possible boundary conditions of EC. A second section describes research about the functional characteristics of EC. The research that is reviewed suggests that EC can be observed under conditions different from those that allow for other forms of PC. The third section focuses on models of EC and the extent to which they are able to account for the functional characteristics of EC. We conclude the article by summarizing the knowledge on EC that has been gained over the past 25 years and by pointing to important unresolved issues that need to be addressed in future research.

## Generality

### *Nature of Stimuli*

*The visual domain.* Although the term *evaluative conditioning* was first coined by Martin and Levey in 1978, an earlier article of theirs (Levey & Martin, 1975) described and used what has become known as the "picture-picture" EC paradigm. In their experiment, participants were presented with a series of 50 visual stimuli in the form of pictures of paintings. In the first phase of the experiment, participants were asked to categorize each picture as liked, disliked, or neutral. Participants were then asked to choose the two pictures they liked the most and the two they liked the least. These four pictures served as the USs. Pictures that participants judged to be neutral were selected as CSs. Levey and Martin then assigned each CS to one US, thus creating four CS-US pairs, two neutral-liked and two neutral-disliked pairs. They also created a neutral-neutral pair by selecting two additional neutral pictures. This control pair served as a baseline against which to compare shifts in the liking of the CSs of each neutral-liked and neutral-disliked pair.

During the acquisition phase, all CS-US pairs were presented 20 times. In a third phase, participants were required to rate all 10 pictures that had been presented during the acquisition phase (the four CSs, four USs, and two control stimuli) on a scale ranging from -100 (*maximum disliking*) to 100 (*maximum liking*). They were instructed to base their judgments on their spontaneous and global impressions. Levey and Martin (1975) demonstrated that pairing a neutral stimulus (CS) with a liked one (US) shifted participants' evaluation of the former in a positive direction, whereas participants' evaluation shifted in a negative direction when the neutral stimulus was paired with a disliked stimulus. The effect of the negative US was stronger than that of the positive US.

A number of other researchers subsequently extended and refined Martin and Levey's original picture-picture EC paradigm. Baeyens and colleagues (Baeyens, Crombez, Van den Bergh, & Eelen, 1988; Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Baeyens, Eelen, & Van den Bergh, 1990; Baeyens, Eelen, Van den Bergh, & Crombez, 1989a; Baeyens, Eelen, Van den Bergh, & Crombez, 1989b, 1992; Baeyens, Hermans, & Eelen, 1993; De Houwer, Baeyens, Vansteenwegen, & Eelen, 2000) repeatedly obtained EC effects using the picture-picture paradigm. Hammerl and Grabitz (1993, 1996) have also replicated the basic EC effect

using the picture-picture paradigm but with pictures of outdoor sculptures rather than photos of faces or paintings. EC with visual stimuli has also been observed in a number of consumer research studies (e.g., Grossman & Till, 1998; Kim, Allen, & Kardes, 1996; Kim, Lim, & Bhargava, 1998; Shimp, Stuart, & Engle, 1991; Stuart et al., 1987) where pictures or the names of fictitious products were used as CSs and pleasant pictures as USs.

Although there is considerable evidence to suggest that EC in the visual domain is a reliable phenomenon, there have also been a number of failures to replicate the standard effect. For example, Todrank (unpublished, as cited in Rozin, Wrzesniewski, & Byrnes, 1998) failed to obtain a significant EC effect in an experiment using the same stimuli and procedures as Baeyens and colleagues (e.g., Baeyens, Eelen, Crombez, & Van den Bergh, 1992). Likewise, Field and Davey (1999) failed to obtain EC effects in the picture-picture paradigm when they randomly assigned CSs to USs. They argued that the EC effects reported in the early studies (Baeyens et al., 1988, 1989a; Baeyens, Eelen, & Van den Bergh, 1990; Levey & Martin, 1987) might have been artifacts that arose due to the stimulus assignment procedures that were used. We discuss the importance of CS-US assignment later in this review. For now the reader should note that there have been failures to replicate EC with visual stimuli. These failures raise concerns regarding its robustness and suggest that the boundary conditions of EC are yet to be fully understood (Rozin et al., 1998).

*The gustatory domain.* Zellner, Rozin, Aron, and Kulish (1983) were the first to study EC with gustatory stimuli. Participants received two kinds of flavored tea, one of which was presented in compound with a sugar solution (CS+) and the other in plain water (CS-). The specific flavors used as the CS+ and CS- were counterbalanced across participants. When the flavors were presented in unsweetened form during a subsequent test phase, there was a preference (as indicated by evaluative ratings) for the flavor that previously had been paired with sugar. This finding of an evaluative enhancement for a neutral flavor contingently paired with sweetness was replicated in three separate studies varying in a number of aspects of stimulus presentation and context.

Baeyens, Eelen, Van den Bergh, and Crombez (1990) attempted to conceptually replicate and extend Zellner et al.'s (1983) findings. They used artificial fruit flavors as the CSs. Like Zellner et al., they used sugar as a positive US but they also incorporated a negative US in the form of Tween, which is a harmless substance with a soaplike taste. Each participant repeatedly received one flavor (CS+) in compound with the US (either sugar or Tween) and one flavor (CS-) in plain water. Results showed that in the negative US (Tween) condition, ratings for the CS+ flavor were significantly lower than those for the CS- flavor.

In the positive US (sugar) condition, however, the EC effects were nonsignificant. Similar failures to replicate the findings of Zellner et al. (1983) have also been reported by Rozin et al. (1998). There are two possible reasons for the fact that gustatory EC effects with positive USs tend to be less reliable. First, positive USs such as sugar tend to be perceived as less extremely valenced than negative USs such as Tween. In support of this hypothesis, Baeyens, Eelen, Van den Bergh, and Crombez (1990) observed that the CS/positive-US compounds were not liked as much as the CS/negative-US compounds were disliked. Second, it is possible that people possess a negative learning bias. A bias of this kind

means that organisms tend to have a predisposition to learn associations involving harmful USs more readily than those involving beneficial USs. It is likely that such a bias might have evolved because of the survival advantages it conferred (Rozin, 1986; Zahorik, 1979). Note, however, that although gustatory EC effects with positive USs tend to be unreliable, the effects are very reliable when negative USs are used (see Baeyens, Crombez, De Houwer, & Eelen, 1996; Baeyens, Crombez, Hendrickx, & Eelen, 1995; Baeyens, Hendrickx, Crombez, & Hermans, 1998; Baeyens, Vanhouche, Crombez, & Eelen, 1998).

*Cross-modal domain.* Until now we have looked only at within-modality EC effects. However, an interesting question is whether EC can occur when the CS and US are of different modalities. Several studies have demonstrated such cross-modal EC effects with a variety of stimuli, including CSs and USs from visual–auditory modalities (geometric shapes and music, Bierley, McSweeney, & Vannieuwkerk, 1985; Greek letters and music, Eifert, Craill, Carey, & O'Connor, 1988; fictitious brand name and music, Blair & Shimp, 1992; picture of a pen and music, Gorn, 1982) and visual–olfactory modalities (positively and negatively valenced pictures and odors, Hvasta & Zanuttini, 1989; photos of liquid soap bottles and odors, Hermans, Baeyens, & Natens, 2000; photographs of faces and odors, Schneider et al., 1999; Todrank, Byrnes, Wrzesniewski, & Rozin, 1995; Wrzesniewski, McCauley, & Rozin, 1999; abstract paintings and odors, Van Reekum, Van den Berg, & Frijda, 1999). Researchers have also used a stressful task as a US and olfactory stimuli as the CS (Epple & Herz, 1999; Kirk-Smith, Van Toller, & Dodd, 1983; Hermans & Baeyens, in press).

Research undertaken by Todrank et al. (1995) warrants closer scrutiny, because their findings reveal the existence of possible boundary conditions. In the studies of Todrank et al., visual stimuli (photographs of human faces) were used as CSs and olfactory stimuli (pleasant or unpleasant odors) as USs. The CSs were randomly assigned to odors that participants had previously rated as liked, neutral, or disliked. During the acquisition phase, participants were exposed to a series of photograph–odor pairings. At test, the photographs were represented without the odors, and participants were required to rate them a second time. Participants' ratings of the photographs shifted in a direction congruent with the valence of the contingently presented odors. However, Todrank et al. noted that evaluative shifts occurred only when the odors used were "plausibly human" (e.g., chemical imitations of naturally produced odors such as sweat or scented products applied to the body such as soap). When odors typically associated with objects rather than people were used, no EC occurred. This finding suggests that when there is not a believable connection between an odor and its apparent source, conditioning is less likely to occur.

There also have been several failures to obtain significant EC effects in cross-modal studies. Rozin et al. (1998) reports that Todrank was unable to obtain EC effects in a number of unpublished studies using odors as CSs and valenced pictures as USs (rather than odors as USs and pictures as CSs, as was the case in the studies of Todrank et al., 1995). Rozin et al. (1998) also carried out an EC experiment using odors as CSs and pictures as USs. The only significant evaluative shift obtained in the predicted direction was that for the CS paired with one of the negative USs (a photo

of a cockroach). In an attempt to enhance the EC effect, Rozin et al. conducted a subsequent study using a more potent negative US in the form of a real dead cockroach. In addition, another strong negative US was included (a photo of Adolf Hitler). However, the only CS to show significant evaluative shifts was the one paired with the dead cockroach. Baeyens et al. (Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Baeyens, Vansteenwegen, De Houwer, & Crombez, 1996) also reported failures of cross-modal EC. They failed to find an EC effect when colors were used as CSs and flavors as USs. In the same studies, however, the valence of the (negative) flavor USs did transfer to flavor CSs (see above).

Overall, the numerous demonstrations of cross-modal EC suggest that the phenomenon is reliable. However, the existence of failures to observe cross-modal EC suggests that the nature of the relation between the CSs and USs can be important. The results of Todrank et al. (1995), for instance, suggest that factors such as belongingness can play a role in EC.

*The haptic domain.* Hammerl and Grabitz (2000) applied the EC paradigm to haptic stimuli (such as the touch of silk or sandpaper). Throughout their experiment, different objects were placed inside a box that had a textile tube attached. Participants touched a stimulus with their fingertips by passing their hand through the tube into the box. During a first phase, participants judged how much they liked the feel of the different objects. CSs and USs were selected on the basis of these initial judgments. Each participant then received several presentations of two different neutral–liked pairs (i.e., first touch something that feels neutral, then touch something that feels nice) and two different neutral–neutral control pairs (i.e., sequentially touch two objects, both of which feel neutral according to the initial ratings). After the learning phase, participants were again asked to judge how much they liked the touch of the CS objects. Hammerl and Grabitz found evidence of EC: CSs that had been paired with liked stimuli received significantly more positive ratings than the neutral stimuli of the control pairs. At present, evidence for EC in the haptic domain is limited to the series of three studies undertaken by Hammerl and Grabitz (2000). Further research is thus required.

*Biologically significant USs.* In the traditional PC paradigm, biologically significant stimuli (such as food or electric shocks) are used as USs and defensive or appetitive responses (such as skin conductance or salivation) are used as measures of learning. In contrast, EC studies have typically used second-order USs that are not biologically relevant. There have been several demonstrations of EC with biologically significant USs, however. For example, Zanna, Kiesler, and Pilkonis (1970) demonstrated that words that predicted the onset of a shock during an acquisition phase were later rated as more negative, whereas words that predicted the absence of shock became more positive (also see Vansteenwegen, Crombez, Baeyens, & Eelen, 1998). Likewise, Johnsrude, Owen, Zhao, and White (1999; see also Johnsrude, Owen, White, Zhao, & Bohbot, 2000) obtained EC effects when neutral monochrome patterns were used as CSs that were paired with a food reward (US) or no food reward.

EC with biologically significant USs has rarely been studied, because the CS–US contingency is often obvious in such experiments and demand artifacts are thus likely. To avoid these problems, an indirect measure of EC can be used. The affective priming

task is one of those indirect measures.<sup>1</sup> In a standard affective priming task, a positive or negative target stimulus is presented on each trial and participants are asked to respond as quickly as possible on the basis of the valence of the target. Each target stimulus is preceded by a prime stimulus that can be positive, negative, or neutral. Results typically show that the time taken to evaluate the target stimuli is mediated by the valence of the primes; when the prime and target have the same valence, response times are significantly shorter than when both stimuli have a different valence. Research showed that this effect is based on the automatic processing of the valence of the prime (see Fazio, 2001, for a review). Hence, the affective priming paradigm provides an unobtrusive means of assessing the acquired valence of a CS that is much less likely to be biased by demand effects than standard verbal evaluative ratings. For instance, if the presentation of the CS as a prime leads to faster processing of negative than positive targets, this indicates that the CS has acquired a negative valence. Because affective priming effects are based on automatic processes, such a result cannot be attributed to demand effects.

Hermans, Vansteenwegen, Crombez, Baeyens, and Eelen (in press) used pictures of human faces as CSs and an electric shock as a US. Stimulus valence was assessed by verbal ratings as well as the affective priming procedure. Participants were initially shown and asked to rate the valence of a set of 60 pictures of faces. Two pictures that had been rated as neutral were selected as CSs. During the acquisition phase, one picture (CS+) was contingently followed by a shock and a second (CS-) was never followed by a shock. After this phase, participants rerated the CSs. In the subsequent affective priming task, the CS+ and CS- were followed by either positive or negative target nouns. Overall, EC was evidenced by a significant decrease in participants' ratings of the CS+ from pre- to postacquisition and by a significant interaction between prime type (CS+ or CS-) and target valence (positive or negative) in the affective priming task. Reaction times in this task were faster on trials where the CS+ was followed by a negative target or the CS- was followed by a positive target than on other trials. The results of Hermans et al. (in press) provide sound evidence for EC with biologically significant USs.

**Observational EC.** Observational EC refers to the phenomenon whereby an individual is indirectly exposed to CS-US contingencies by means of observation of another individual who is either really or ostensibly being exposed to a CS-US contingency and reacting to a US. In an experiment by Baeyens, Vansteenwegen, et al. (1996), children consumed a series of neutral colored and flavored drinks while simultaneously watching a videotaped actor drinking identical drinks and facially displaying either displeasure or a neutral expression. Specific counterbalanced flavors of the drinks functioned as the CS+ or CS- and were systematically paired with the actor's facial expression (displeasure vs. neutral). That is, whenever the participant received a drink with the CS+ flavor, the model displayed a negative expression, and whenever the participant received a drink with the CS- flavor (or color), the model displayed a neutral expression. Results showed that participants subsequently rated the CS+ flavor more negatively than the CS- flavor. Baeyens, Eelen, Crombez, and De Houwer (2001) recently replicated and extended these findings.

**Real-life contexts.** To date, few researchers have explored EC in real-life contexts. However, two field studies by Baeyens, Wrzesniewski, De Houwer, and Eelen (1996) used odors as CSs

and real-world contexts as USs. In their first study, for instance, Baeyens, Wrzesniewski, et al. paired particular odors (CS) with toilets as the US. During an "acquisition phase," an odor (either lavender or pine) was dispensed in two bathrooms that were situated in different parts of an office building. Baeyens, Wrzesniewski, et al. found that after a week, participants who subjectively enjoyed bathroom activities evaluated the toilet-paired odor more positively than the control odor, whereas the reverse was true for those who subjectively disliked bathroom activities. Similar results were obtained in a second study in which odors were used as CSs and a massage as the US.

However, other real-life studies have produced less convincing findings. In a study by Rozin et al. (1998), shampoo fragrances functioned as a CS and hair washing as either a positive or neutral US activity. Participants were divided into those who subjectively rated hair washing as a highly enjoyable activity (positive US group) and those who rated it neutrally (neutral US group). Rozin et al. found no difference between the mean CS ratings in the positive US group and the neutral US group. Rozin et al. also found no effect in a second study in which participants were asked to smell odors (CSs) while engaging in positive, neutral, or negative activities (USs).

Overall findings from real-life settings have been somewhat equivocal. However, to date only a few studies of this kind have been undertaken, and more research is required.

### *Procedural Parameters*

Now that we have examined the generality of EC with regard to the type of stimuli to which it can apply, we summarize studies that looked at whether EC varies as a function of certain procedural parameters.

**Backward versus forward conditioning procedures.** Unlike the standard forward conditioning procedure in which the CS precedes the US, in a backward conditioning preparation the US is presented prior to the CS. This more closely resembles the circumstances found in many consumer and marketing contexts, where advertisers frequently present the US (e.g., a smiling face) before displaying the product they are trying to sell (i.e., the CS; Stuart et al., 1987). As is the case with other forms of PC, EC effects are smaller with backward than with forward conditioning procedures (Hammerl & Grabitz, 1993; Stuart et al., 1987). Nevertheless, significant EC effects have been found even when a backward procedure was used (Martin & Levey, 1978; Stuart et al., 1987).

**Number of pairings.** Some studies found a significant increase in EC with increasing numbers of pairings (different numbers

<sup>1</sup> Some researchers (e.g., Hamm & Vaitl, 1996; Lipp, Sheridan, & Siddle, 1994; Vansteenwegen et al., 1998) have used startle modulation as an indirect measure of acquired stimulus valence. However, it should be noted that there are problems with using the startle response as an index for EC because it can be used only to differentiate between positive and negative stimuli at high levels of stimulus arousal (Cuthbert, Bradley, & Lang, 1996). Therefore, when startle measures provide evidence for EC under certain but not other conditions, it is unclear whether this informs about the conditions under which EC occurs or the conditions under which CSs evoke high levels of arousal as a result of the conditioning procedure (Vansteenwegen et al., 1998). For this reason, we do not discuss the results of EC studies with startle measures further.

between 0 and 20 pairings; e.g., Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Sachs, 1975; Staats & Staats, 1959). Other studies did not reveal a significant effect of the number of pairings (Martin & Levey, 1987; Stuart et al., 1987), but even in those studies there was at least a tendency for the EC effect to increase with increasing number of pairings. One should note, however, that some studies have successfully demonstrated conditioning with only a single CS-US pairing (Stuart et al., 1987) and that, at least in the picture-picture paradigm, EC effects can start to decrease in magnitude with very high numbers (i.e., 20) of pairings (Baeyens, Eelen, Crombez, & Van den Bergh, 1992).

**CS-US assignment.** In Levey and Martin's (1975) original picture-picture paradigm, CSs and USs were selected on the basis of affective judgments made by participants during a preacquisition phase. In addition, CS-US pairs were constructed on the basis of perceptual similarity. That is, a neutral picture (CS) was assigned to a positive picture (US) if it was most similar to that picture with regard to form, content, or color but to a negative picture if it was most similar to that picture. Shanks and Dickinson (1990) and Field and Davey (1997, 1998, 1999) correctly pointed out that such a CS-US assignment procedure could result in artifactual EC effects. It is possible, for example, that participants need to see a number of examples of the pictures before they can get a good idea of what the most positive and most negative pictures are within the set. By the time they have identified these anchor points, they might already have evaluated some pictures as neutral that, once they have set their anchor points, they might actually regard as positive or negative because of the perceptual similarity to the pictures they chose as anchors. Therefore, when participants are asked to evaluate the pictures for a second time (i.e., after acquisition), they may rate CSs that are similar to positive USs as more positive than CSs similar to negative USs regardless of whether the CS-US pairs were presented (De Houwer et al., 2000). According to this logic, a participant's rating of a CS may increase or decrease simply because of its perceptual similarity to a positive or negative US rather than because of the CS-US pairings.

The fact that CS-US assignment based on perceptual similarity can lead to artifactual EC effects was empirically supported by Field and Davey (1999). They found evidence of EC when CS-US pairs were constructed on the basis of perceptual similarity but not when CSs were randomly allocated to USs. In addition, when CS-US pairs were constructed on the basis of perceptual similarity, the magnitude of the so-called EC effects was the same regardless of whether the CS-US pairs were actually presented.

However, Field and Davey's (1997) artifactual account is relevant only to a limited number of studies. With the exception of some, but not all, of the studies by Martin and Levey (1978, 1987; Levey and Martin, 1975) and three of the early experiments by Baeyens and colleagues (Baeyens et al., 1988, 1989a; Baeyens, Eelen, & Van den Bergh, 1990), most studies have not used a CS-US assignment based on perceptual similarity. Instead, in all recent picture-picture experiments, CSs were randomly assigned to USs (Baeyens et al., 1989b, 1993; Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Baeyens, Eelen, Van den Bergh, & Crombez, 1992; De Houwer et al., 2000; Hammerl & Grabitz, 1993, 1996). In all flavor-flavor studies (Baeyens, Crombez, et al., 1995, 1996; Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Baeyens, Hendrickx, et al., 1998; Baeyens, Vanhouche, et al., 1998;

Zellner et al., 1983), CSs and USs were selected on an a priori basis and the CS-US assignments were counterbalanced across participants. The same applies to the observational EC studies (Baeyens et al., 2001; Baeyens, Vansteenwegen, et al., 1996), to experiments on odor conditioning (Baeyens, Wrzesniewski, et al., 1996; Todrank et al., 1995; Van Reekum et al., 1999), and to recent studies using the verbal conditioning paradigm (De Houwer, Baeyens, & Eelen, 1994; De Houwer, Hendrickx, & Baeyens, 1997). In most advertising EC studies, CSs and USs were selected a priori and CSs were randomly assigned to USs (Blair & Shimp, 1992; Grossman & Till, 1998; Kim et al., 1998; Stuart et al., 1987). Because these studies did not use the problematic assignment of CS to USs on the basis of perceptual similarity, the artifactual account of Field and Davey (1999) does not apply.

Moreover, the fact that constructing CS-US pairs on the basis of perceptual similarity can cause artifacts does not necessarily invalidate the early picture-picture studies. A reanalysis of the data from the early studies revealed that the observed effects were not related to CS-US similarity (see Baeyens & De Houwer, 1995, for more details). Finally, De Houwer et al. (2000) recently obtained a significant EC effect in the picture-picture paradigm despite using random assignment of CSs to USs and prescanning instructions. One could argue that although randomization radically reduces the probability that the artifact identified by Field and Davey (1999) can operate, it does not completely eliminate the possibility that CSs will be more similar to the US to which they have been assigned than to other USs. To counter this argument, De Houwer et al. (2000) asked participants to first scan through all the pictures to select anchors before assigning preacquisition ratings. By allowing participants to select anchors before giving their initial ratings, one can eliminate possible effects of CS-US similarity when such a similarity is still present despite random CS-US assignment. The fact that a significant EC effect emerged in the study of De Houwer et al. (2000) thus provides strong evidence for the associative nature of EC.

To conclude, assignment of CS-US pairs on the basis of perceptual similarity should be avoided because it introduces a potential artifact. Instead, random assignment of CSs to USs should be made—preferably in conjunction with the prescanning task introduced by De Houwer et al. (2000)—or the CS-US assignment should be counterbalanced. Alternatively, between-participants control conditions can be used. A consideration of the nature and usefulness of these between-participants controls forms the focus of the following section.

**Control condition.** In the majority of EC studies, within-participant designs have been used in which each participant sees at least two different types of CS-US pairs (CS-liked US, CS-disliked US, or CS-neutral US). EC is said to have occurred if the evaluation of the CSs varies as a function of the valence of the US to which they have been assigned. As mentioned above, in most studies such designs have been used in combination with control measures (i.e., randomization or counterbalancing of the assignment of CSs to USs) that are generally considered to be adequate (e.g., Shanks & Dickinson, 1990). However, Field and Davey (1997, 1998) have argued that even well-controlled within-participant designs are inadequate because they cannot definitely rule out the possibility that EC is the result of nonassociative processes. They have criticized randomization procedures on the grounds that they do not completely eliminate the possibility of

systematic differences (such as perceptual similarity between CSs and USs) occurring by mere chance. In addition, they have argued that in counterbalanced designs it is impossible to conclusively demonstrate EC unless baseline measures of CS valence are taken. This is because if by chance the CSs were not initially neutral, apparent valence changes simply may have been due to these baseline disparities. Instead they propose that to infer beyond any doubt that associative learning has occurred, it is necessary to include a between-participants control condition in which all associations are eliminated.

Field and Davey (1997) proposed two types of between-participants control groups: a no-treatment control and a block-subblock (BSB) control. In a no-treatment control group, there are no presentations of CS-US pairs during the conditioning phase. Participants are merely asked to rate CSs and USs twice. The purpose of this condition is to control for demand effects and the effects of the general procedure (such as stimulus selection and the repetition of the rating procedure). The goal of the BSB group is to control for stimulus exposure effects. In the BSB control, all experimental stimuli that are shown in the standard group are presented, but to ensure that no stimulus associations are formed, the stimuli are presented in separate CS and US blocks, both consisting of a randomized presentation of subblocks of each of the individual stimuli (for example, 10 times CS<sub>2</sub> followed by 10 presentations of CS<sub>1</sub>, followed by 10 US<sub>1</sub> and finally 10 US<sub>2</sub> presentations). Therefore, the BSB control is a form of unpaired control (see Baeyens & De Houwer, 1995, and Field & Davey, 1997, for a more detailed discussion of the use of unpaired controls in EC research).

Although we believe that the unpaired designs proposed by Field and Davey (1997, 1998, 1999) are valid controls, researchers might want to consider whether it would be a wise use of resources and participants to systematically add such controls to well-designed within-participants experiments. As generally agreed on in the field of experimental psychology and unlike that suggested by Field and Davey (1997, 1998), the likelihood of biases or artifacts arising in within-participant designs is very small indeed provided that rigorous randomization and counterbalancing procedures are implemented. Moreover, an obvious advantage of within-participant controls is that fewer participants are required to achieve acceptable levels of statistical power. These arguments against the necessity of a systematic use of between-participants control groups become especially convincing given the fact that in the recent EC studies using haptic (Hammerl & Grabitz, 2000) and visual stimuli (Díaz, Baeyens, Ruiz, & Sánchez, 2000), the BSB control was indeed included in addition to the usual within-participant controls. In both studies, strong and reliable EC effects were obtained regardless of whether the within- or the between-participants BSB control was taken as the critical point of comparison. Hence, one can safely conclude that regardless of one's theoretical position concerning optimal controls, EC can definitely be shown to be a genuine associative learning phenomenon.

## Conclusions

In the first part of this review, we saw that EC has been demonstrated using a variety of stimuli and procedures. Given the fact that Field and Davey (1999) have demonstrated that a similarity-based construction of CS-US pairs can lead to artifac-

tual nonassociative-based evaluative shifts, random or counterbalanced CS-US assignment should be used as a matter of course. Although the between-participants controls that have been advocated by Field and Davey (1997, 1998, 1999) are undoubtedly valid, so long as a within-participant study is well designed we believe them to be unwarranted because they provide little or no information that is not readily available in the within-participant comparisons.

Despite the fact that there have been numerous well-designed studies that have provided compelling evidence for EC, there have also been several reported failures to find EC in similar, equally well-controlled experiments (e.g., Field & Davey, 1999; Rozin et al., 1998). In addition, there is evidence that there are limitations to the phenomenon. For example, the specificity of the effects obtained in some studies (e.g., Baeyens, Crombez, et al., 1996; Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Todrank et al., 1995) suggests that the nature of the relation between the CS and US may be critical. To conclude, we agree with Rozin et al. (1998) that although the failures to replicate are cause for some concern, rather than calling into doubt the existence of EC, such failures suggest that there are boundary conditions for EC that are yet to be fully understood.

## Functional Characteristics of EC

Although at a procedural level the EC paradigm bears close resemblance to other forms of human classical conditioning, it appears to differ in certain ways at the process level. In the following section, we will discuss the functional characteristics of EC and compare them with those of other forms of PC.

### Extinction

In PC, extinction refers to the phenomenon whereby postacquisition presentations of the CS without the US (i.e., CS-only) lead to the gradual diminution or elimination of the previously acquired conditioned response. Unlike most other forms of PC (Hamm & Vaitl, 1996; Hughdahl & Öhman, 1977), EC appears to be highly resistant to extinction. In the context of the standard picture-picture paradigm, Baeyens et al. (1988, 1989a) found that 5 and even 10 unreinforced presentations of the neutral stimuli did not have any influence on the evaluative value of CSs that was acquired as the result of 10 previous CS-US pairings. However, because the CS-US pairs were constructed on the basis of perceptual similarity in both of Baeyens's extinction studies, caution is required when interpreting the data in light of the possible artifact identified by Field and Davey (1997, 1999). It should be noted, though, that Baeyens and De Houwer (1995) reanalyzed the data from Baeyens et al.'s (1989a) study and found no indication that the artifact operated in that study.

Resistance to extinction has also been demonstrated in studies that did use well-controlled within-participant designs. For example, in the context of the picture-picture paradigm using randomized CS-US assignment and prescanning instructions, De Houwer et al. (2000) assigned participants to either a standard conditioning group or an extinction group. Those in the conditioning group received seven presentations of each of eight CS-US pairs. In the extinction condition, the CS-US pairs were presented in the same way but were followed by five presentations of each CS on its

own. De Houwer et al. (2000) found that there was no significant difference between the sizes of the EC effect obtained in the conditioning and the extinction groups.

Baeyens, Crombez, et al. (1995) found evidence of resistance to extinction in a flavor–flavor study in which counterbalancing of CS–US assignments was used. After an acquisition phase consisting of 6 CS–US pairings, participants received a series of 8 CS-only trials that were divided into two separate test blocks. An equally strong EC effect was evident in the second as in the first block of test trials, despite the fact that the US was never present on those trials. Likewise, Baeyens, Crombez, et al. (1996) found that 6 postacquisition CS-only presentations did not attenuate a flavor dislike that was acquired after 6 CS–US acquisition trials intermixed with 6 CS-only acquisition trials. In another, unpublished study at Baeyens's lab (Baeyens, 1995), EC was obtained when 8 CS–US acquisition trials were, without an intervening postacquisition rating, immediately followed by an equal number of CS-only extinction trials. Finally, in the context of a US revaluation experiment undertaken by Baeyens, Vanhouche, et al. (1998), participants received 12 CS-only trials after 9 acquisition trials. They found that the CS-only trials had no impact on the magnitude of the EC effect.

In two experiments using pictures of faces as CSs and an electric shock as a US, Hermans, Crombez, Vansteenwegen, Baeyens, and Eelen (2000) found that EC as indicated by verbal ratings and affective priming data survived the removal of the electrodes through which the shock was delivered and the implementation of a formal extinction procedure. It is interesting that there was still evidence of EC even when other measures more typical of PC (i.e., US expectancy ratings) did show complete extinction. Similarly, using Japanese letters as CSs and valenced words as USs, Díaz et al. (2000) showed that after 10 reinforced CS–US trials intermixed with 4 CS-only trials (partial reinforcement), a total of 24 postacquisition CS-only trials had not the slightest impact on the magnitude of EC as indexed by both verbal ratings and postextinction affective priming effects.

Overall there is considerable evidence from a variety of conditioning preparations and procedures that relative to most other forms of PC, EC is resistant to extinction. One might of course argue that extinction could occur when the number of extinction trials is increased further. Although further research might thus be necessary, one should note that studies have failed to reveal any reduction at all in the magnitude of the EC effect even when the number of extinction trials was up to twice as large as the number of acquisition trials. These findings clearly differ from what is observed in most other PC studies (e.g., Hamm & Vaitl, 1996; Hugdahl & Öhman, 1977).

### *Statistical Contingency*

Traditional PC studies have demonstrated that the degree of statistical contingency between the CS and the US is critical (e.g., Rescorla, 1968). However, contingency appears to have less of an impact on EC. Baeyens et al. (1993) manipulated the degree of CS–US contingency in the standard picture–picture paradigm. In the perfect contingency condition, the CS and the US were presented 10 times in close temporal contiguity without any additional CS-only or US-only presentations. In the partial reinforcement condition, there were 10 CS–US presentations and an additional 10

CS-only presentations. Finally, in the composite condition, there were 10 CS–US presentations, 10 CS-only, and 10 US-only presentations. Although the conditions differed in degree of statistical contingency, they did not differ with respect to the number of spatiotemporal contiguous CS–US presentations. After rating the valence of the CSs, participants were asked to subjectively estimate the level of CS–US contingency. Baeyens et al. (1993) found that different levels of CS–US contingency did not result in significantly different levels of conditioning. They also found that participants' subjective perceptions of the CS–US contingencies did not correlate with the size of their evaluative shifts. However, although there was no evidence that the size of the conditioning effect was significantly moderated by the level of objective statistical contingency, it should be noted that the differential conditioning effect tended to be larger in the perfect contingency condition than in the other two conditions. The fact that there was no significant effect of statistical contingency might have been related to the low statistical power of the study (only 10 participants per condition).

Although the results of Baeyens et al. (1993) are only suggestive, findings from flavor–flavor modulation studies (Baeyens, Crombez, et al., 1996; Baeyens, Hendrickx, et al., 1998) provide further evidence that EC effects are not dependent on the degree of statistical contingency. In Baeyens, Crombez, et al.'s (1996) first experiment, they found that an acquisition schedule containing six CS+ and six CS-only trials resulted in an equally strong EC effect as a schedule containing six CS+ trials. In their third experiment, participants were exposed to a sequential feature-positive schedule in which the neutral target flavor A was accompanied by Tween when preceded by the feature flavor X, whereas it was presented without Tween when preceded by plain water. They found that participants developed a dislike for target flavor A but not for the feature flavor X despite the fact that flavor X was a much better predictor for Tween occurrence than flavor A. A subsequent unpublished study (Baeyens & De Peuter, 1996) showed that a flavor X can acquire a negative valence when it precedes Tween in plain water (i.e., without flavor A). One can thus argue that flavor X did not acquire a negative valence in the study of Baeyens, Crombez, et al. (1996) because the presentation of flavor A was more contiguous with the presentation of Tween. Finally, in an unpublished study, Baeyens (1994) obtained equally strong EC in a condition where the CS and US were always presented together,  $P(\text{US}/\text{CS}) = 1$ , than in a condition where there were twice as many CS-only than CS–US presentations,  $P(\text{US}/\text{CS}) = .33$ . This pattern of findings suggests that CS–US spatiotemporal contiguity might be more critical than contingency. Nevertheless, the evidence regarding the role of contingency in EC (especially visual EC) is rather limited. Therefore, more research is needed.

### *Contingency Awareness*

In PC, there is evidence to support the hypothesis that conditioning in humans occurs only when participants are aware of the CS–US contingency relationship (for reviews, see Brewer, 1974; Dawson & Schell, 1987; Lovibond & Shanks, in press; Shanks & St. John, 1994). Many studies have addressed the issue of whether contingency awareness is necessary for EC to occur. These have been reviewed comprehensively by De Houwer, Baeyens, and



Hendrickx (1997) and more recently by Field (2000). Here we limit the discussion to what we consider to be the focal issues.

Field (2000) correctly pointed out that one should distinguish between two types of awareness. First, *demand awareness* refers to whether a participant is able to report the experimental hypotheses. Second, *contingency awareness* is whether a participant is aware of the critical CS-US relation. A participant can be demand aware without necessarily being contingency aware and vice versa. For example, a participant might be aware that his or her evaluative judgments are expected to change as a result of the CS-US presentations but not be aware of the specific contingencies involved, or alternatively, a participant might detect the specific CS-US associations without realizing that evaluations of the CS should change.

In EC studies, researchers have attempted to reduce the likelihood of demand awareness by using cover stories. For example, in their picture-picture EC experiments, Baeyens and colleagues have told participants that they were exploring the relationship between subjective evaluations and physiological responding. To enhance the plausibility of the cover story, they told participants that their skin conductance responses were going to be monitored and attached electrodes to their hands (e.g., Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Baeyens, Eelen, & Van den Bergh, 1990). Other researchers have used filler materials to detract participants' attention from the critical CS-US contingency and thus to minimize the likelihood of hypothesis guessing (e.g., Stuart et al., 1987).

Rather than disguising the CS-US contingencies to reduce demand awareness, one can also control for demand awareness in a post hoc manner. For instance, participants can be asked at the end of an experiment what they believed its purpose was (see Allen & Janiszewski, 1989; Kim et al., 1996; Stuart et al., 1987). Those participants who are able to verbalize the hypothesis can be classified as demand aware, and their data can then be excluded from further analysis (but see Shimp, Hyatt, & Snyder, 1991). The final and perhaps most elegant way of circumventing potential artifacts arising from demand effects is to assess EC using an indirect measure such as the affective priming task. Because such tasks are unobtrusive, their outcome is unlikely to be biased by demand effects (e.g., De Houwer, Hermans, & Eelen, 1998; Hermans et al., in press; Olson & Fazio, in press).

In many studies, EC effects have been obtained even when demand-aware participants have been excluded on the basis of postexperimental questionnaires (e.g., Hammerl, Bloch, & Silverthorne, 1997), and they have also been demonstrated with indirect measures such as the affective priming task (e.g., De Houwer et al., 1998; Hermans et al., in press). These findings clearly demonstrate that demand awareness is not necessary for EC to occur, a conclusion that was also reached by Field (2000).

A number of studies went on to explore the role of contingency awareness in EC. There are three types of findings that support the claim that EC is independent of contingency awareness. First, dissociations between awareness and EC have been obtained in several studies. In a study by Baeyens, Eelen, and Van den Bergh (1990), participants either were given explicit instructions to search for CS-US relations or were told a cover story in which no reference was made to CS-US relations. Those in the search condition were required to predict on each acquisition trial which type of picture (liked, disliked, or neutral) would follow the CS on

that trial. All participants received a postexperimental questionnaire that consisted of three types of questions. First, participants were shown the nine neutral pictures and were asked whether they thought that their evaluation of the picture had changed. If they expressed a change they were asked to indicate why they thought this change had occurred. Second, the experimenter asked the participant to select the specific photo that they thought had followed each of the CSs during the conditioning phase. Finally, if a participant was unable to select a specific US for a given CS, he or she was asked whether it had been followed by a liked, disliked, or neutral US during the experiment. Participants were also required to indicate their degree of confidence (sure, rather sure, rather unsure, unsure). Participants were judged to be aware of a particular CS-US contingency if (a) they correctly indicated the US that was paired with the CS, (b) they indicated a different US but with the same valence, or (c) they were unable to indicate a particular picture but correctly expressed the evaluative value of the US. In addition, participants were required to be either "sure" or "rather sure" of their answer.

Instructions to search led to increased contingency awareness as measured by the postconditioning questionnaire: Participants in the search condition were able to report 77% of all CS-US associations, whereas those participants who had received the cover story knew only 18%. However, the size of the EC effect did not differ significantly between the two groups. It should be noted that this study has been criticized by Field (2000) on the basis of its low statistical power. Field also argued that the awareness assessment was biased toward classifying participants as unaware. The latter criticism is, however, based on an incorrect reading of Baeyens, Eelen, and Van den Bergh (1990).

Several other variables have been shown to have a differential effect on awareness and EC. Baeyens, Eelen, Crombez, and Van den Bergh (1992) manipulated the number of acquisition trials that participants received. They found that although levels of awareness were greater when there were 20 presentations of each CS-US pair as opposed to 10, the EC effect decreased in size. In addition, Baeyens et al. (1989b) showed that whereas manipulations of the degree of CS-US similarity had no impact on EC, participants' awareness of the CS-US relationships was significantly enhanced when the stimuli were similar relative to when they were dissimilar.

Finally, Baeyens, Eelen, Van den Bergh, and Crombez (1990) observed a double dissociation between EC and awareness in the context of a flavor-flavor study. They assessed contingency awareness by means of a short postconditioning questionnaire in which participants were asked to identify which US (sugar or Tween) had been paired with which CS (a particular flavor or a particular color) and were then required to indicate how confident they felt about their response. Although approximately half of the participants were contingency aware when colors were used as the CSs, no evaluative changes occurred. In contrast, when flavors were used as the CSs, none of the participants were contingency aware but large evaluative changes did occur.

A second line of evidence that supports the independence of EC and awareness comes from correlational data. The general finding reported in the literature is that the magnitude of the EC effect that is displayed by a participant is unrelated to the number of CS-US associations that the participant is aware of. This suggests that higher levels of awareness do not necessarily result in stronger



evaluative shifts (e.g., Baeyens et al., 1988, 1993; Baeyens, Eelen, Crombez, & Van den Bergh, 1992). In fact, some studies even found a negative correlation between awareness and EC (e.g., Hammerl & Grabitz, 2000).

A final way of assessing whether contingency awareness is a prerequisite for the occurrence of EC is to use subliminal stimulus presentations. The rationale behind this approach is that if the CS or US of a CS-US pair is presented subliminally, it is unlikely that participants will acquire conscious knowledge of that association. In a study by Niedenthal (1990), participants were presented with images of a novel cartoon character (CS). For some participants, the CS was preceded by a subliminal picture of a face (US) expressing joy, for others the face expressed disgust, and for the remainder the face had a neutral expression. At a later test stage, participants in the disgust US group endorsed more negative traits as descriptive of the cartoon than those in the joy condition.

In two studies by Krosnick, Betz, Jussim, and Lynn (1992), a target stimulus (various photos of one person) was preceded by subliminal presentations of affectively laden photos. The valence of the US (positive vs. negative) was counterbalanced across participants. After the acquisition phase, participants were required to rate the target person on a series of affective dimensions. The positive US group rated the target person more positively than the negative US group.

A study by De Houwer et al. (1994) used words instead of pictures as the stimuli in a subliminal EC study. Whereas the studies of Niedenthal (1990) and Krosnick et al. (1992) used a between-participants design that did not control for possible non-associative mood effects induced by the subliminally presented stimuli, De Houwer et al. (1994) used a within-participant design that did control for such nonassociative effects. Neutral words (CSs) were either followed by a subliminally presented positive or negative word (US). Despite the fact that participants were unaware that the USs had been presented, they nevertheless demonstrated a preference for those words that had previously been paired with positive USs over those that had been paired with negative ones. De Houwer, Hendrickx, and Baeyens (1997) reported a series of four follow-up experiments. They obtained significant EC effects in only two out of the four experiments, and even then the size of the overall effects was small. Nevertheless, a meta-analysis carried out by De Houwer, Hendrickx, and Baeyens that drew together the data from the five experiments indicated a significant EC effect, albeit with a relatively small effect size ( $r = .21$ ).

Overall, the weight of empirical evidence appears to suggest that EC does not depend on contingency awareness. However, in a critical review of the literature Field (2000) argued that such a conclusion might be premature on the grounds of certain statistical and methodological problems related to the measurement of awareness. In particular, he argued that most studies have failed to fulfill Shanks and St. John's (1994) information and sensitivity criteria. According to the information criterion, a measure of awareness should be directed at uncovering all relevant conscious information that a participant has, including information that differs from but is correlated with the covariations that were presented during the learning phase. The sensitivity criterion, on the other hand, specifies that the awareness measure should be sensitive enough to detect all relevant conscious knowledge about the covariations (see Shanks & St. John, 1994, for a more detailed

discussion of these criteria). However, De Houwer, Baeyens, and Hendrickx (1997) argued that dissociations between EC and awareness cannot be criticized on the basis of the information and sensitivity criteria because of two characteristic features of the EC paradigm. First, because evaluative shifts can be attributed only to (implicit or explicit) knowledge of the valence of the US that was paired with the CS, awareness measures that ask participants to report their knowledge of this information do satisfy the information criterion (as Shanks & St. John, 1994, acknowledged). Such awareness measures have been used in most relevant EC studies (e.g., Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Baeyens, Eelen, & Van den Bergh, 1990; Baeyens, Eelen, Van den Bergh, & Crombez, 1990, 1992; Baeyens et al., 1993). Second, whereas implicit learning studies most often focus on the learning of a single rule, in EC studies, several CS-US associations are presented to a single participant and awareness is assessed for each individual association. Thus, even if the awareness measure is not optimally sensitive, as long as the information criterion is met, it follows that differences in the number of associations participants report during the awareness test will reflect actual differences in their levels of awareness. De Houwer, Baeyens, and Hendrickx (1997) argued that the combination of these two characteristics enables certain conclusions to be drawn about awareness. If awareness is necessary for EC, then a significant change in the number of associations that participants report on an awareness measure should be accompanied by a similar change in EC even when the awareness measure is not optimally sensitive. The fact that dissociations and nonsignificant correlations have been obtained in a number of experiments therefore strongly suggests that EC does not depend on contingency awareness. Evidence from the subliminal conditioning studies provides further evidence for this hypothesis. It must be noted, however, that the effect sizes obtained in the subliminal studies were quite small. Nevertheless, this might be due to the fact that fewer CS-US pairings tend to be used in subliminal studies or that the impact of the USs is reduced as a result of them being presented subliminally.

### *Occasion Setting*

Another way in which EC seems to differ at a process level from other types of PC is that it does not appear to be susceptible to the effects of modulation or occasion setting. In a typical PC feature-positive schedule, a CS is reinforced if, and only if, it is accompanied by another stimulus (the feature). In PC, this results in a conditioned response if the CS is preceded by the feature but not if the CS is presented alone (e.g., Holland, 1983, 1991; Rescorla, 1985, 1991). However, Baeyens and colleagues (Baeyens, Crombez, et al., 1996; Baeyens, Hendrickx, et al., 1998) failed to obtain similar results in a number of flavor-flavor EC studies.

In a first experiment, Baeyens, Crombez, et al. (1996) used the color of the compound fluids as the feature, a particular fruit flavor as the CS+, and Tween as the negative US. No evidence was obtained for the acquisition of a color-modulated flavor-flavor association: Participants acquired only an unmodulated dislike for the CS+ flavor. In their third experiment, another flavor rather than color was used as the feature in a sequential feature-positive preparation. However, as in Experiment 1, this resulted only in an unmodulated dislike for the target flavor. Baeyens, Hendrickx, et al. (1998) explored whether increasing the number of acquisition

trials would enhance the likelihood of modulation effects. They used a sequential feature-positive preparation in which flavors were used for both feature and target. In line with previous findings, participants did not acquire a modulated dislike for the target flavor.

### *Counterconditioning*

Other features of EC parallel those obtained in more traditional PC preparations. For example, EC demonstrates sensitivity to counterconditioning procedures. Baeyens et al. (1989a) conducted a picture-picture EC study that started with a standard baseline measurement phase and an acquisition phase consisting of 10 presentations of each CS-US pair. After the acquisition phase, some of the CSs were involved in a counterconditioning treatment. Counterconditioning entailed 10 pairings of each of those CSs with a new US of a valence opposite to the valence of the US with which it was previously paired. For instance, if a CS had originally been paired with a liked US during acquisition, it was followed by a disliked US in the counterconditioning phase. Other CSs were presented 10 times on their own during the second phase (extinction), whereas still other CSs were not presented during the second phase (control). After the second phase, participants were required to rerate the valence of all CSs. Results showed that the liking of extinction and control CSs increased from baseline to test if they were paired with a positive US during acquisition but decreased if they were paired with a negative US. In contrast, the liking of the CSs that were submitted to a counterconditioning treatment was the same on baseline and test.

In a sequential feature-positive experiment undertaken by Baeyens, Hendrickx, et al. (1998, Experiment 4), participants were exposed to the target flavor together with a harmless unpleasant taste (Tween) if it was preceded by the feature flavor X but received the target flavor together with sugar when it was preceded by plain water. For those participants who liked sugar, no valence shifts were observed, whereas participants who disliked sugar developed an unmodulated dislike for the target flavor. Thus when sugar was liked it counteracted the effect of the Tween because the target flavor was paired equally often with a liked (i.e., sugar) and a disliked (Tween) US. However, when sugar was disliked it supported the effect of the Tween because the target flavor was in effect always paired with a negative US (i.e., either sugar or Tween).

### *Postacquisition Revaluation*

EC also appears to be sensitive to postacquisition revaluation of the US. In the postacquisition US revaluation procedure, a CS-US pair is first presented and then the US is revalued in the absence of the CS (for example, an originally positive US is made neutral or negative). Finally, the CS is tested alone. Baeyens, Eelen, Van den Bergh, and Crombez (1992) explored US revaluation in the context of the picture-picture paradigm using photos of faces as stimuli. USs were revalued by presenting them together with incongruent information in the form of hypothetical personality descriptions (consisting of five negative or positive adjectives presented auditorily). These verbal descriptions purportedly described the personality of the person depicted in each of the US photos. In the acquisition phase, participants were presented with pairs of neutral

(CSs) and valenced (USs) photos. In a subsequent phase, half of the USs were revalued by being presented in combination with incongruent information (e.g., a liked US accompanied by five negative adjectives and vice versa), whereas the other half of the USs were presented in combination with congruent information and thus not revalued. During the subsequent test phase, participants were required to assign ratings to the CSs. One month later participants were retested. Baeyens, Eelen, Van den Bergh, and Crombez (1992) found that postacquisition revaluation did affect the acquired value of the CSs. Ratings for CSs paired with USs that had subsequently undergone successful revaluation shifted in the same direction as the USs had shifted, and this effect remained at follow-up.

However, two flavor-flavor experiments reported by Baeyens, Vanhouche, et al. (1998) failed to demonstrate postacquisition revaluation effects (even though revaluation did strongly affect the liking of the US). Baeyens, Vanhouche, et al. (1998) hypothesized that these seemingly discrepant revaluation findings may be attributed to the different characteristics of the USs in the picture-picture paradigm compared with the US used in the flavor-flavor paradigm. They suggested that photos of faces may induce much more elaborate sensory encoding than simple gustatory stimuli such as the bad taste (Tween) that is used as a US in the flavor-flavor studies. They suggested that revaluation effects in flavor-flavor studies might be more likely if the complexity of the gustatory US were increased.

### *Sensory Preconditioning*

EC demonstrates sensitivity to sensory preconditioning procedures (Hammerl & Grabitz, 1996), paralleling findings from other PC research (Brogden, 1939; Kimmel, 1977). Sensory preconditioning typically involves three phases: In the first phase, a CS<sub>1</sub> is paired with a different CS<sub>2</sub> (e.g., a light and tone). Next, CS<sub>2</sub> is repeatedly paired with a US. When CS<sub>1</sub> is presented alone during a final test phase, it elicits a conditioned response (CR) that is appropriate to the US that was paired with CS<sub>2</sub>, even though CS<sub>1</sub> has never been directly paired with the US. Hammerl and Grabitz (1996) used photos of outdoor sculptures and fountains to explore sensory preconditioning in EC. Participants were initially presented with pairs of neutral stimuli (CS<sub>1</sub> and CS<sub>2</sub>). In a second phase, CS<sub>2</sub> was paired with a positive or neutral US on several trials. Finally, at test, participants were required to assign a rating to CS<sub>1</sub>. Hammerl and Grabitz observed that the ratings for CS<sub>1</sub> underwent an evaluative shift in the direction of the US paired with CS<sub>2</sub> even though CS<sub>1</sub> had never been paired with the US.

### *US Pre- and Postexposure*

In PC, the US preexposure effect refers to the well-documented phenomenon whereby exposure to a series of US-only presentations prior to acquisition reduces the magnitude of the CR to the CS that was paired with that US during acquisition (e.g., Randich & Lolordo, 1979). Hammerl et al. (1997) used photos of outdoor fountains and sculptures to explore whether this effect would also be obtained in an EC paradigm. In two experiments, they found that US preexposure did lead to a reduction in EC. Hammerl et al. suggested that a possible explanation for this effect might be that repeated presentations of the US lead to a reduction in its affective

value and thus in weaker emotional responses. What is interesting is that they also found evidence of US postexposure effects. That is, EC effects diminished as the result of postacquisition presentations of the USs on their own. Hammerl et al. argued that the USs might have lost some of their affective value as a result of the postacquisition US-only trials. One could thus argue that the USs were implicitly revalued and that this affected the ratings of the CSs in the same way as explicit postacquisition revaluation of USs influences CS ratings (Baeyens, Eelen, Van den Bergh, & Crombez, 1992). According to this interpretation of the data, US postexposure effects can thus be regarded as evidence for postacquisition US revaluation.

The presence of significant US pre- and postexposure effects in EC might seem surprising in light of the apparently limited effect of reducing the CS-US contingency by introducing US-only trials during the learning phase. One should note, however, that the picture-picture study of Baeyens et al. (1993) did reveal a tendency for smaller EC effects when US-only trials were added to the learning phase. This (nonsignificant) effect might therefore also be linked to increased habituation to the USs as a result of a higher number of US-only trials.

### *CS Preexposure*

CS preexposure (or latent inhibition) refers to the phenomenon in PC whereby preexposure to the CS retards the development of a CR. Stuart et al. (1987) explored CS preexposure in an advertising context. Participants were exposed to a neutral CS (brand) prior to a conditioning phase in which the CS was paired with a positively valenced US either 1 or 10 times. Those in the single pairing condition received 8 preexposures of the CS, and those in the 10 pairings condition received 20 preexposures. In line with findings from the PC literature, CS preexposure retarded conditioning relative to a condition with no CS preexposures.

De Houwer et al. (2000) recently explored CS preexposure in the context of the picture-picture paradigm. Participants assigned to a CS preexposure condition were shown each CS on its own on five trials prior to the acquisition phase that consisted of seven presentations of each CS-US pair. Overall, the preacquisition trials did not significantly reduce the magnitude of the EC effect relative to a control condition with no CS preexposures. However, separate analyses revealed that the EC effect was not significant for those in the CS preexposure group, whereas it was significant for the control group. Moreover, it is possible that significant CS preexposure effects would have emerged if more CS-only trials had been presented. Although the results of De Houwer et al. (2000) were thus fairly consistent with those of Stuart et al. (1987), more research is needed before any definite conclusions can be drawn.

### *Conclusions*

We can see that there seem to be functional differences between EC and PC. Unlike other forms of PC, EC appears to be (a) resistant to extinction, (b) driven by simple contiguity rather than statistical contingency, (c) unaffected by modulation procedures, and (d) independent of contingency awareness. However, certain effects typical of PC (such as counterconditioning, revaluation, sensory preconditioning, US pre- and postexposure, and CS preexposure effects) have also been obtained in the context of EC.

Although the results suggest that there are qualitative differences between the functional characteristics of EC and other forms of PC, more research is needed. One problem with the existing evidence is that the EC studies differ from typical PC studies in a number of ways. It is thus possible that the differences between the results of EC and other PC studies were due to procedural discrepancies rather than to genuine differences in the processes that underlie EC and other forms of PC.

One way of resolving this is to apply measures that are commonly used in EC studies (e.g., verbal evaluative ratings and the affective priming task) in combination with those typical of traditional PC studies (e.g., measures of skin conductance responses). Hermans et al. (2000, in press) have already adopted this approach in several of their studies. Using a differential aversive conditioning procedure with pictures of human faces as CSs and an electric shock as the US, they obtained measures typical of PC (expectancy and fear ratings) in addition to indices of EC (verbal valence ratings and response times on an affective priming task). As noted earlier, they found that whereas the expectancy and fear responses did show near complete extinction, this was not the case for either the valence ratings or the affective priming task measures. Thus an extinction procedure had a differential impact on those measures more typical of PC than on those typical of EC. More research of this kind is required if we are to establish whether the functional differences between PC and EC reside primarily at the procedural or process level.

### *Models of EC*

Having reviewed the evidence regarding the conditions under which EC can be observed, we now discuss the various models of EC and the extent to which they are compatible with the reported findings.

#### *The Conceptual-Categorization Account*

Davey (1994) has questioned whether EC is a genuine associative learning phenomenon and argued that it instead reflects a type of conceptual learning. He has pointed out that neutrally valenced CSs are likely to contain both liked and disliked features. The process of pairing a CS with a US may highlight those features in the CS that are conceptually congruent with the US but that were not salient prior to conditioning. A participant might then recategorize the CS on the basis of these newly salient features. Applied to the picture-picture paradigm, the logic is as follows: If a CS is paired with a liked US, then the liked features that are shared by the CS and US will become more salient in the CS, resulting in the participant liking the CS more. Conversely, if a CS is paired with a disliked US, then the disliked features may become more salient, resulting in the participant disliking the CS more. As an example, when an evaluatively neutral face with the features of brown eyes, long shape, full lips, and long hair is paired with a US containing the features of blue eyes, round shape, full lips, and long hair, it may be that the salience of the liked features of the CS (full lips, long hair) increases, such that the originally neutral face is now seen as liked. Davey argued that what appear to be shifts in valence that depend on the formation of a CS-US association may instead be based on such a nonassociative conceptual recategorization process. Thus, according to this account evaluative shifts arise as

a consequence of the pairing procedure but not necessarily through the establishment of a CS-US association in memory.

Baeyens, De Houwer, Vansteenwegen, and Eelen (1998) have pointed out several weaknesses in Davey's (1994) nonassociative categorization model of EC. First, such an account would have difficulty explaining the cross-modal conditioning effects that have been demonstrated in the literature. It seems unlikely that there would be enough commonality between cross-modal stimuli to permit conceptual recategorization. Second, in its present form it cannot explain the selective nature of postacquisition US revaluation effects that have been documented. For example, using the picture-picture paradigm, Baeyens, Eelen, Van den Bergh, and Crombez (1992) showed that when CS<sub>1</sub>-liked-US<sub>1</sub> and CS<sub>2</sub>-liked-US<sub>2</sub> pairings are followed by a revaluation into a neutral direction of liked US<sub>1</sub> but not of liked US<sub>2</sub>, CS<sub>1</sub> but not CS<sub>2</sub> loses its acquired positive valence. Although it is conceivable that a US revaluation procedure may change a participant's criteria for the "liked face" category and that these new criteria may lead to a subsequent change in the perception of CS<sub>1</sub>, what Davey's account cannot explain is why the value of CS<sub>2</sub> is unaffected by the revaluation procedure. Presumably, if the criteria for the liked face category are changed, they should apply equally well to CS<sub>2</sub> as to CS<sub>1</sub>.

### *The Holistic Account*

Martin and Levey (1978, 1994; Levey & Martin, 1975), both prominent learning psychologists, turned their attention to EC because they believed that EC plays a fundamental role in PC. They argued that many of the associatively induced changes in overt behavior that are used to index PC rely on the transfer of valence from the US to the CS. In their view, EC depends on a primitive mechanism that operates in all animals. In more evolved animals, such as humans, EC can be supplemented by additional learning, such as learning to predict the occurrence of events on the basis of other events (Martin & Levey, 1994). The primitive and fundamental transfer of valence is thought to arise as the result of the formation of a *holistic representation*. Such a holistic representation is formed as the direct and automatic result of the contiguous presentation of a CS and US. It represents the stimulus elements of the CS and US, as well as the evaluative nature of the US. Once such a holistic representation has been formed, the CS can activate the holistic representation and thus the evaluation that was associated with the US. This will result in a change in the valence of the CS in the direction of the valence of the US.

The finding that EC effects are resistant to extinction supports a holistic account. Once a holistic CS-US representation has been formed, the CS will activate this representation during extinction and thus the evaluation of the US. Because the CS will by itself evoke the valence of the US, the nonappearance of the US should not have an impact on the acquired valence of the CS. Moreover, the finding that contingency awareness is not a prerequisite for EC is also consistent with the notion that holistic representations are formed automatically. Finally, the holistic account is also compatible with the results of US revaluation studies. To the extent that the holistic representation also includes stimulus elements of the US, the US will activate the holistic representation during revaluation. As a result, the new information about the valence of the

US can then be integrated in the holistic CS-US representation and afterward be activated by the CS.

The holistic account has more difficulties explaining sensory preconditioning results. As noted above, Hammerl and Grabitz (1996) showed that the liking of a CS<sub>1</sub> can change even when it was never paired with the US but only with another neutral stimulus (CS<sub>2</sub>) that itself was paired with the US. Given that holistic CS-US representations are formed only when the CS and US were presented together, one would not expect sensory preconditioning to occur. One could argue, however, that pairing CS<sub>1</sub> with CS<sub>2</sub> results in a holistic representation that is activated during the CS<sub>2</sub>-US trials and that during these trials the valence of the US is integrated in the holistic CS<sub>1</sub>-CS<sub>2</sub> representation.

### *The Referential Account*

Baeyens, Eelen, Crombez, and Van den Bergh (1992) proposed a model that is very similar to the holistic model of Martin and Levey (1987, 1994) in that both models lead to fairly similar predictions. However, the approach that they took differs somewhat from that of Martin and Levey. Whereas the latter regard EC as a core element of PC, Baeyens, Eelen, Crombez, and Van den Bergh (1992) proposed that PC (defined as associatively induced changes in appetitive or defensive preparatory responses to the CS) and EC (defined as associatively induced changes in the valence of the CS) can be regarded as two different forms of learning. They argued that at a phenomenological level, conventional preparatory PC can be described as a form of signal or expectancy learning whereas EC can be thought of as a form of merely referential learning. In most PC preparations, the CS becomes a signal for the presence of the US; the CS generates an expectancy about the US—that is, a belief that the US is actually going to occur in the near future. In EC, however, it seems as if the CS merely makes one (consciously or unconsciously) think of the US without activating an expectancy that the US is actually going to occur.

In more recent articles, Baeyens and colleagues (Baeyens & De Houwer, 1995; Baeyens, Eelen, & Crombez, 1995) elaborated on this idea. They argued that an expectancy or signal learning system forms the basis of preparatory PC whereas a referential system underlies EC. The expectancy system is thought to be responsible for the detection of reliable and nonredundant predictors of significant events. It reacts to the presence of such predictors by activating responses that prepare the organism for the occurrence of the significant event. The system responds only to reliable and nonredundant predictors because the activation of preparatory responses places a high load on the organism's limited energy and information-processing resources. Because of the heavy involvement of limited-capacity information-processing resources, PC is typically accompanied by an awareness of the CS-US relation. The hypothesis that preparatory PC depends on the operation of the expectancy system is compatible with the observation that PC is sensitive to extinction, contingency manipulations, and modulation. Extinction, contingency manipulations, and modulation determine the extent to which a CS is a reliable predictor of the US at a particular point in time. Because response activation by the expectancy system depends on the extent to which the CS is a current reliable predictor of the US, PC will be sensitive to these variables.

EC, however, is assumed to depend on the operation of a referential system. The referential system is less sophisticated than the expectancy system in that it is only sensitive to co-occurrences between neutral and valenced events. When a stimulus is encountered, the referential system will automatically determine its valence by averaging across the valence of the stimuli with which the stimulus co-occurred in the past. This will then shape the organism's behavior toward the stimulus in that liked stimuli will tend to be approached whereas disliked stimuli will tend to be avoided. Behavior is most likely to be influenced by the referential system in choice-preference-evaluation situations, involving low response cost, or low differential response cost (Baeyens, Eelen, & Crombez, 1995).

The referential model of EC is compatible with a large number of findings. Because the referential system is sensitive only to co-occurrences between events, situations in which the events do not co-occur will not influence its operation. This allows the model to explain why EC is not sensitive to extinction, contingency manipulations, or modulation. Counterconditioning does affect EC because during counterconditioning, the CS does co-occur with a valenced event. Revaluation can also be explained. Changes in liking as determined by the referential system occur because the presentation of the CS activates the representation of the US with which it co-occurred. If, however, the representation of the US is altered during revaluation, the CS will activate this altered US representation during test. US postexposure effects can also be explained if one assumes that postacquisition US-only presentations result in a revaluation of the US. Also, EC should not depend on awareness of the CS-US contingencies because the referential system operates in an automatic fashion. Finally, effects of CS and US preexposure can be explained if one assumes that such preexposures reduce the salience of the stimulus and thus weaken the increases in associative strength as a result of CS-US pairings.

The referential model as formulated by Baeyens et al. (Baeyens & De Houwer, 1995; Baeyens, Eelen, & Crombez, 1995) can be characterized as a functional model rather than as a computational or algorithmic model (Marr, 1982). Both the expectancy and the referential system are described in functional terms, and the properties of PC and EC are explained on the basis of the function of the underlying system. The model does not specify, however, what processes allow the systems to perform their function, nor does it commit itself to a certain algorithmic implementation of these systems. Baeyens (1998) and De Houwer (1998) noted that there are several ways in which the model can be specified at a computational and algorithmic level. First, one can think of the referential system as a completely separate and distinct system that depends on the operation of a different learning rule and influences other aspects of behavior than the expectancy system. For instance, one could assume that associations in the referential system are formed on the basis of a simple Hebbian learning rule that increases the strength of an association between two stimuli whenever the stimuli co-occur but leaves the association strength intact when one of the two stimuli are presented in isolation. Such Hebbian associations could be stored separately from the associations that are formed in the expectancy system. Unlike the Hebbian associations that form the basis of the referential system, associations in the expectancy system could be determined by a competitive delta rule that updates the strength of a CS-US association according to the extent to which the CS is a reliable and

nonredundant predictor of the US (e.g., Rescorla & Wagner, 1972). Some responses (e.g., preferences and choice behavior) will depend on the associations stored by the referential system, whereas other responses (e.g., preparatory responses) will reflect associations as stored by the expectancy system.

According to a second computational view of the distinction between the referential and expectancy systems, both do depend on the same learning rule and associative knowledge base but differ in the way in which this acquired knowledge is translated into behavior (De Houwer, 1998). Recent findings suggest that preparatory PC is based on a relatively simple learning mechanism but that performance is based on a complex translation of stored associations. For instance, research by Bouton (1993, 1998) and Rescorla (1996) demonstrated that although an extinction procedure results in a decrease of conditioned Pavlovian responses, it does not seem to affect the strength of the underlying association. Rather than changing the strength of existing CS-US associations, extinction seems to result in the learning of additional associations—either inhibitory CS-US associations (e.g., Wagner, 1981) or excitatory CS-context associations (e.g., Miller & Matzel, 1988)—that modulate the extent to which the original associations influence behavior. Likewise, some data suggest that redundant CSs do enter into an association with the US but that these associations are not expressed in behavior (e.g., Denniston, Savastano, & Miller, 2001; Miller & Matzel, 1988). These findings suggest that both the expectancy and referential systems rely on the same associative knowledge base that stores information about the extent to which stimuli co-occur (e.g., in the form of excitatory CS-US and CS-CS associations) and information about the extent to which stimuli do not co-occur (e.g., in the form of inhibitory CS-US associations or excitatory associations involving the US and other CSs). The expectancy system retrieves and compares both types of information to determine the extent to which a CS is a reliable and nonredundant predictor of a US (see Denniston et al., 2001, for a possible way in which such a comparison can be achieved). The referential system, however, takes into account information about only those co-occurrences involving the CS it needs to evaluate.

Although these computational views provide further details about how one could conceptualize the referential model of EC, the model remains speculative and is too vague to allow one to derive new precise predictions. Also, Baeyens and colleagues (e.g., Baeyens, Eelen, & Crombez, 1995) do not clearly specify which responses are guided by the referential system. One could argue that the referential system determines only likes and dislikes. However, this hypothesis seems to be contradicted by the results of recent studies by Stevenson and colleagues (Stevenson, Boakes, & Prescott, 1998; Stevenson, Boakes, & Wilson, 2000; Stevenson, Prescott, & Boakes, 1995). They demonstrated that judgments about the sweetness of a flavor (CS) can be altered by pairing the flavor with sugar (US). These changes occurred independently of changes in liking of the flavor. It is important to note that associatively induced changes in flavor perception were resistant to extinction and did not depend on awareness of the CS-US contingency. Conditioning of flavor perception thus appears to show the functional characteristics that one would expect of conditioning that is supported by the referential system. If, however, it is true that both EC and conditioning of flavor perception depend on the operation of the referential system, this would imply that the

referential system influences not only liking responses but also other nonaffective responses. This would of course raise the question as to which nonaffective responses are influenced by the referential system. At present, however, evidence for the involvement of the referential system in types of conditioning other than EC is limited to the conditioning of flavor perception. As Stevenson et al. (2000) argued, it is possible that the conditioning of flavor perception is somehow special because flavor stimuli are processed in a more holistic way than visual stimuli. It would thus be interesting to examine whether the results of Stevenson and colleagues can be extended to visual stimuli.

### Conclusion

We described three models of EC that are all able to explain some of the functional characteristics of EC. Both the holistic and referential model are able to account for most of the functional characteristics of EC. Also, recent computational formulations of the referential model (De Houwer, 1998) provide some suggestions as to how the functional differences between EC and PC can be reconciled theoretically. It should be clear, however, that all models have serious shortcomings. First, they are primarily functional or descriptive models that do not clearly specify the processes that underlie EC. Because of this, it is difficult to derive precise quantitative predictions or even qualitative predictions that would allow one to test or differentiate between the models. Second, none of the models has anything to say about the boundary conditions to which EC is clearly subjected. One should note, however, that although many theories of conventional preparatory PC are superior in that they provide more details about the processes, most of those theories also fail to specify the boundary conditions of PC, such as the selectivity with regard to the types of CS-US associations that can be learned. One should also note that progress in the development of theories of EC is hampered by the fact that evidence about the functional characteristics of EC is currently limited and somewhat equivocal. As we noted earlier, studies are needed in which measures of EC and PC are compared within the same paradigm. Finally, there are currently no data about the role of cue competition in EC. Just as findings of cue competition had a major impact on theories of PC (e.g., Rescorla & Wagner, 1972), it is likely that data on cue competition in EC will have a major impact on theories of EC.

### Summary and Conclusions

In this article, we reviewed the large body of studies on EC that have been conducted since the seminal article of Levey and Martin (1975) was published 25 years ago. What have we learned about EC during this period? First, EC has been demonstrated using a large variety of stimuli and procedures. One can thus conclude that EC is robust and ubiquitous. At the same time, however, there have been some troublesome failures to obtain EC effects. Whereas some failures can be expected to occur because of statistical reasons, other failures (e.g., Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Field & Davey, 1999; Rozin et al., 1998) appear to be genuine and point to the existence of boundary conditions that are not yet fully understood. Identifying and understanding these boundary conditions should be an important aim of future research.

Second, Field and Davey (1997, 1999; also see Shanks & Dickinson, 1990) identified an important potential problem with the early picture-picture studies of Levey and Martin (1975; Martin & Levey, 1978) and Baeyens et al. (1988, 1989a; Baeyens, Eelen, & Van den Bergh, 1990). This led to a number of procedural improvements such as randomized or counterbalanced assignment of CSs to USs and the use of between-participants control conditions. Because numerous studies demonstrated EC when using adequate controls and CS-US assignment procedures, there can be little doubt about the fact that EC is a genuine form of associative learning.

Third, a relatively small number of studies examined the functional characteristics of EC. The results of these studies suggest that EC is different from PC in a number of ways. However, some have argued that these differences are due to procedural differences between typical EC and conventional preparatory PC studies (with regard to, e.g., the number of trials, timing of events, or nature of the stimuli) rather than to actual differences in the processes that underlie both types of conditioning. Therefore, more research is needed before definite conclusions can be drawn. Ideally, such research should look at dissociations between measures of EC and measures of preparatory PC within the same experiment, because if differences between EC and PC are found, then these cannot be attributed to procedural elements (e.g., Hermans et al., 2000; in press; Vansteenwegen et al., 1998).

Finally, the various models of EC that have been described in this review can account for most of the empirical findings reported in the literature. However, these models tell us little about the specific processes that underlie EC and thus do not permit the formulation of precise hypotheses. It is therefore imperative that existing theories are reexamined and refined or that new models are proposed. Emphasis should be placed on exploring and delineating the boundary conditions of EC.

Despite the fact that much work still needs to be done, EC research has provided important insights into the development of preferences. Given that preferences have an important impact on human behavior, this knowledge provides insights into the many aspects of human behavior. We now know beyond any reasonable doubt that preferences can be created by pairing neutral stimuli with affective stimuli. This provides ways to shape the way people behave toward new or previously neutral stimuli such as products, people, or ideas. Some research also suggests that EC does not depend on awareness of the critical pairings. This is in line with the observation that people often have little insight into the reasons behind their preferences and behavior (e.g., Zajonc, 1980). It is possible that such implicit preferences often develop as the result of EC. Research also provided important information about how to alter preferences that have been learned through EC. For instance, merely presenting a stimulus in isolation (i.e., extinction) appears to have little effect on the acquired valence of that stimulus. To change acquired preferences, it seems to be more effective to either pair the stimulus with another stimulus of the opposite valence (i.e., counterconditioning) or to reevaluate the affective stimulus that was originally paired with that stimulus (i.e., US revaluation). This insight is particularly useful for the treatment of affective disorders, where one of the main aims is to change problematic affective responses to certain stimuli (e.g., Baeyens et al., 1988; Hermans, 1998). As noted above, however, many findings in EC research need further empirical confirmation, and several impor-

tant questions are still left open. We hope that this review will provide an impetus for further research that will address these issues.

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Received October 6, 2000

Revision received March 16, 2001

Accepted March 23, 2001 ■